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JANUARY 2003

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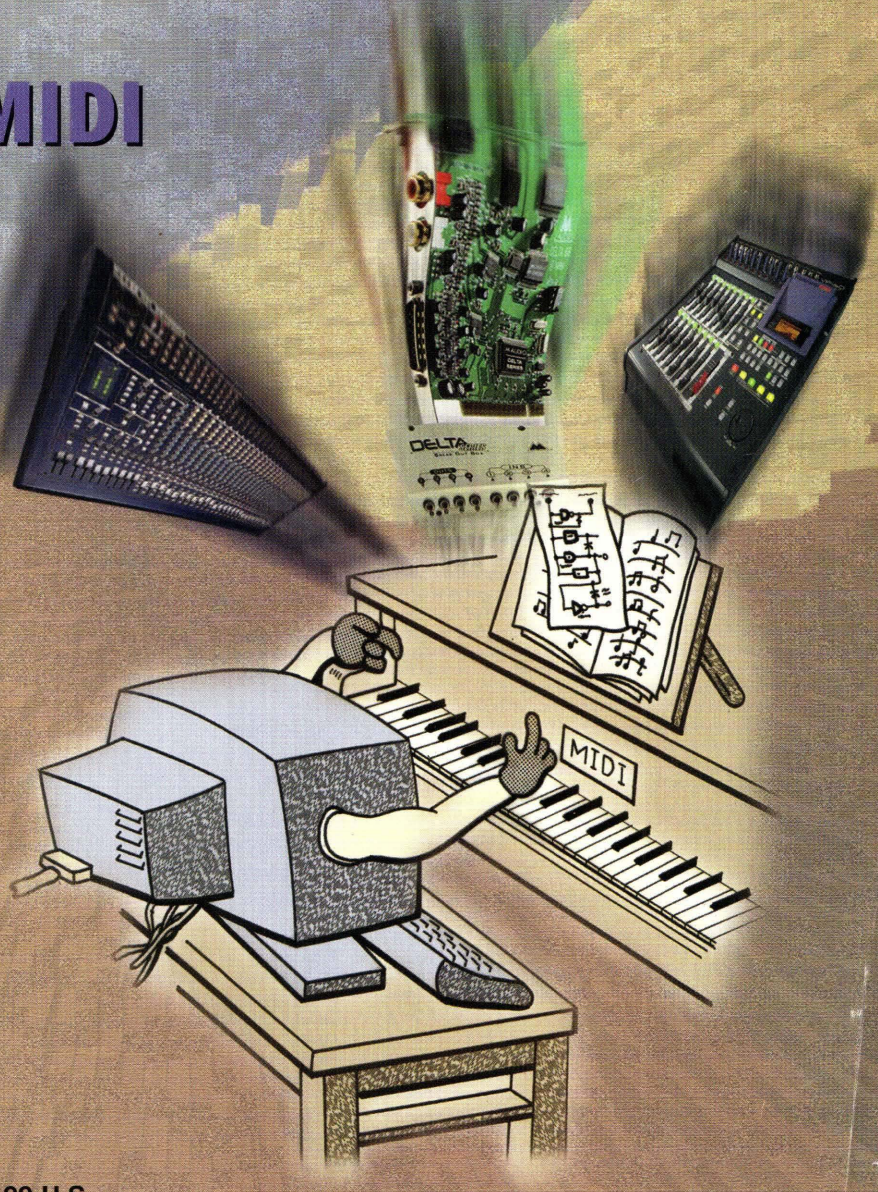

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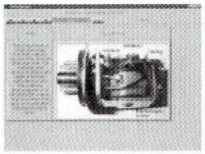

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Electronics Now

January 2003, Vol. 4, No. 1

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Poptronics (ISSN 1526-3681) Published monthly by Gernsback Publications, Inc. 275-G Marcus Blvd., Hauppauge, NY 11788. Second-Class postage paid at Hauppauge, NY and at additional mailing offices. One-year, twelve issues, subscription rate U.S. and possessions $24.99, Canada $34.81 (includes G.S.T. Canadian Goods and Services Tax Registration No. R125166280), all other countries $35.99. Subscription orders payable in U.S. funds only, International Postal Money Order or check drawn on a U.S. bank. U.S. single copy price $4.99.
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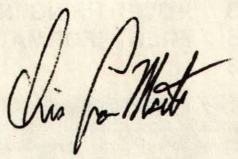
Electric Entertainment

What was your first form of electric entertainment? Can you remember, or have you been told of a time, when you were first perched in front of a television and allowed to bask in its radiation? Or was it a radio that was broadcasting drama and news invisibly through the air? Sometime in the near future a child will receive his first dose of electric entertainment from a *Multi-Media Center*. The Center is a hodge-podge of electric entertainment devices crammed into a neat package weighing less than twelve pounds and it takes up less space than the dog. At night, the Center can play an audible lullaby accompanied with a shimmering light show that radiates from a plasma screen above the crib. Stay tuned...technology is about to become part of the family, if you let it.

On a lighter note...it's 2003 and I think we should all adopt Barry Manilow's "Looks Like We Made It" as a global theme song. Any takers? Well, leave all your troubles outside and take a look at this special issue in your hands. Our main topic is electronic music. We'd like to refresh and introduce our readers to different topics, such as MIDI and home recording. Also in the mix is Part 2 of the *Mapper8* construction article, as well as fine installments by our columnists. Please note: *Prototype* will return in a new format and a possible audio column is on the horizon. Let me let you in on another scoop: Coming up in June, we will present our 95th Anniversary Issue. That's right...95 years of Hugo-inspired innovation. It's going to be a very special issue. You'll see. We've been sorting through the archives and cleaning the dust off the history-laden warehouse in order to bring a retrospective to our readers. Now, I have to get back to work on February's magazine, so open up the rest of this wonderful periodical and enjoy!

Happy New Year,



Chris La Morte

NEW GEAR

For more information go to page 80A

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Multimedia RF Video Generator

Portable and lightweight, the *Multimedia RF Video Generator* ($2495) delivers HDTV, NTSC, and computer-display video signals. The battery-powered unit accurately aligns front and rear projectors, monitors, direct-view displays, and video walls—in all operating modes. It also provides patterns for black level, white balance, focus, and convergence alignment. Some other features include component-video and RGB-video output, 4:3 and 16:9 aspect ratios, and ATSC HDTV and standard-definition formats.

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3200 Sencore Dr.
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Audio Analyzer

Offering a real-time, sound-pressure level meter, with energy-time graph abilities and reverb-decay time acoustic measurements, the *SP295 SoundPro Audio Analyzer, Contractor's Version* ($2495) is ideal for commercial analysis. The instrument assesses line-level input signals from external microphone preamps, mixers, and audio processors. Additional features include a sound study graph; signal-to-noise ratio; impedance, amplitude response, and sine wave sweeps; monitor amplifier; and time-code tool functions.

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Equipped with a hard and wear-resistant point, the *Tungsten-Carbide Tip Scriber* ($5.60, or $7.20 with magnet) is great for fine-precision marking on materials such as hardened steel, glass, ceramic, hard plastic, and circuit board. The scriber has a 5½-inch, knurled handle with a convenient pocket clip, and it is also available with a hardened-steel or diamond point.

MOODY TOOLS, INC.
60 Crompton Ave.
East Greenwich, RI 02818
800-866-5462 or 401-885-0911
www.moodytools.com

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Solder Paste

Made with synthetic poly adducts, this no-clean *Solder Paste* (call supplier for price) is ideal for in-circuit testing of fine-pitch solder joints. Offering improved compatibility with OSPs (*o*rganic *s*olderability *p*reservatives), it also works with all no-lead formulations, including tin/silver/copper alloys. With up to 18 hours of stencil life, the paste requires no refrigeration; and it's available in jars, cartridges, syringes, and cassettes.

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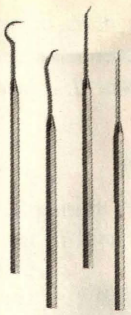
Probe Set



These *10-mil Precision Probes* (55-1784) ($37.44) have stainless steel tips and hex-shaped non-roll aluminum handles. Designed for fine-pitch applications below 25 mil, the probes allow lead straightening, testing, and cleaning of solder joints. They come with tip protectors and are packaged in PVC tubes for protection.

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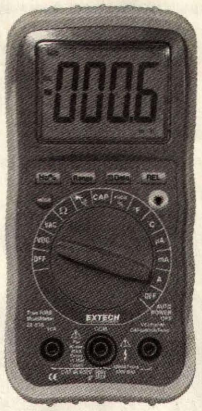
Autoranging Multimeter



Rugged and compact, the *True RMS Autoranging Multimeter, Model 22-816* ($99) provides accurate readings of distorted AC voltage and current waveforms. It measures AC/DC voltage, AC/DC current, resistance, capacitance, frequency, temperature, and duty cycle. Added functions include diode and continuity tests, data and range hold, relative zero, and auto power off. The meter also features an oversize, backlit LCD display; offers fuse and overload protection; and is bundled with a rubber holster, test leads, and a probe.

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285 Bear Hill Rd.
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www.extech.com
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Counting Scale

Able to weigh and count small parts to 0.01% (FS) accuracy, the battery-operated *Counting Scales, Models 160272* and *160275* ($599) feature direct PC connection via the RS-232 interface. Counts and weights can be transmitted directly to a printer or PC, and the printout can include an ID/reference number. Weight capacity—6 lbs. (model 160272) and 15 lbs. (model 160275)—is displayed with 0.005 lb. and 0.001 lb. resolution, respectively, or as net/gross. The display is easy to read on the bright LCD window.

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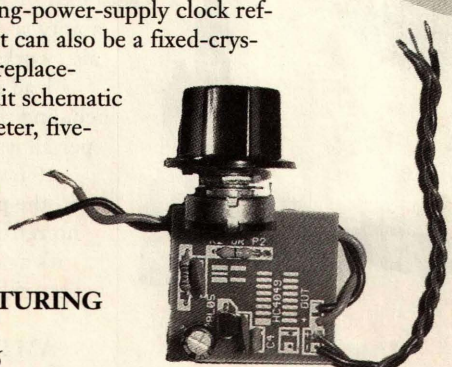
VFO Circuit Kit

Designed with the amateur-radio enthusiast in mind, the *VFO Circuit Kit, 80-1410 VF0* ($15.99) replaces the crystals in transmitter and receiver circuits. In addition to providing a precision oscillator that is also a switching-power-supply clock reference, the kit can also be a fixed-crystal oscillator replacement. A circuit schematic for a forty-meter, five-watt CW transmitter is included, as well.



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PowerPack

Providing 300 watts of portable AC power, the *XPower Powerpack 300 Plus* ($129.99) is perfect for jump-starting a car, truck, or boat. In addition, it has a built-in air compressor with a nozzle adapter to pump air into tires or small inflatable sports equipment. Built with a 20-amp-hour battery, the unit provides 300 watts of household electricity—enough to power a cordless phone for up to 40 hours and a laptop computer for six.

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925-245-5400
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NEW LITERATURE

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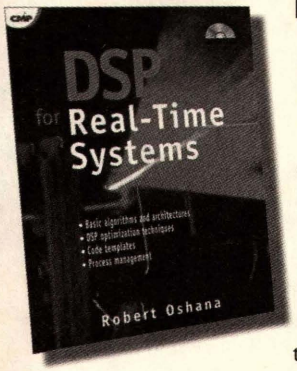
Colorful and compact, this catalog offers over 300 robotics kits, books, electronics, videos, and more. Just to name a few-there's the AIBO ERS220, Nano Muscles, a CMUcam vision system, and flying saucers. Also featured are robot sensors and brains, motors, drivers, tools, and batteries–everything necessary for robot assembly and creation. The Web site offers information and instructions on many products, and schools and groups can receive a discount on bulk orders.

DSP For Real-Time Systems



by Robert Oshana
CMP Books
1700 Fourth St.
Berkeley, CA 94710
800-788-3123
www.cmpbooks.com
$49.95

Serving as a practical guide to the technical and management processes for developing DSP applications in real-time and embedded systems, this book covers both software and hardware issues. These issues include DSP architecture, algorithms, optimization, the use of development tools, integrating and testing, and project management. The accompanying CD-ROM contains many useful DSP design tools.

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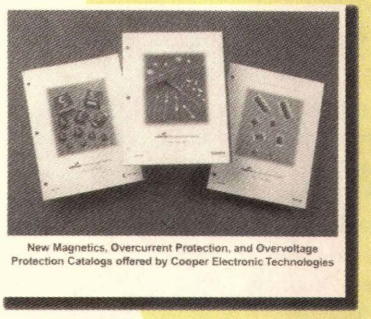
Three guides are available. The 136-page guide for the line of Bussman electronic fuses aids engineers in the selection of over-current protection solutions. The 84-page guide for the Coiltronics inductors has more than 700 different part numbers for various requirements and configurations. Finally, the 16-page guide to SurgX overvoltage products presents information on how to protect sensitive electronic circuits from damage due to ESD.



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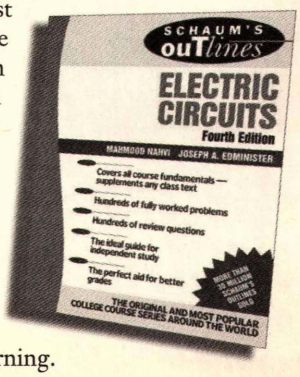
Schaum's Outline Of Electric Circuits, Fourth Edition

by Mahmood Nahvi and Joseph A. Edminister
McGraw-Hill
2 Penn Plaza, 12th Floor
New York, NY 10121
800-2MCGRAW
www.books.mcgraw-hill.com
$16.95

Updated to cover the latest circuit analysis course requirements, this edition gives readers a thorough foundation in the theory and operation of electric circuits. It combines brief explanations of theory with illustrative examples, 364 solved problems, and supplemental problems-altogether providing a direct, effective tool for learning.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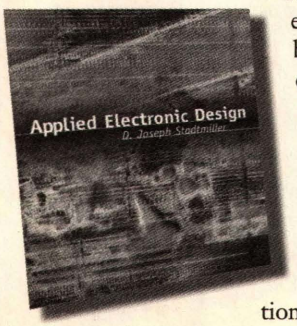
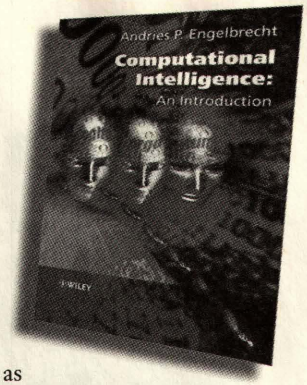


An excellent reference for entry-level electronic design engineers, this book presents complete discussions of the design process and issues relating to a wide range of electronic applications. It focuses on the concurrent engineering setting, including manufacturability, quality service, and customer criteria. Chapters cover printed circuit board design, component selection, oscillators and signal generators, and control circuits.

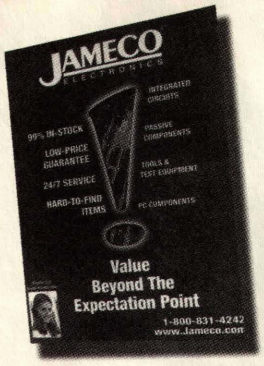
Computational Intelligence: An Introduction



by Andries Engelbrecht
John Wiley & Sons, Inc.
10475 Crosspoint Blvd.
Indianapolis, IN 46256
877-762-2974
www.wiley.com
$55

Can a computer think? This text examines the question, defining the term as adaptive mechanisms that enable intelligent behavior in complex and changing environments. The book ranges from the fundamentals, such as in-depth treatments of frequently used techniques, to recent developments. Complete algorithms in pseudo-code for easy implementation are featured, making it an ideal reference for computer science students.

Components Catalog from Jameco Electronics



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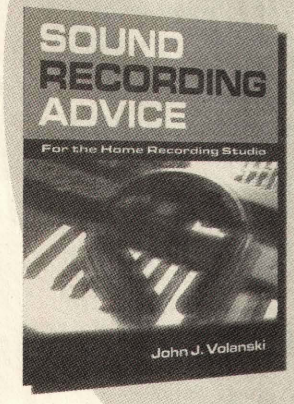
There are over 390 products in this 192-page catalog, including power components, test equipment, network accessories, computer products, memory microprocessors, programmable devices, and breadboards. An ideal resource for everyone from hobbyists to professionals, the catalog features products from Power One, Digital Power, Volgen, and Integrated Power Designs, among others.

Sound Recording Advice

by John J. Volanski
Pacific Beach Publishing
P.O. Box 90471
San Diego, CA 92169
www.johnvolanski.com
$19.95

A complete reference for the home studio owner, this book covers everything from buying the right recording equipment to understanding technical concepts. The author explains in detail how to set up mikes, mix down multiple tracks, build simple pieces of equipment, troubleshoot, and more. He also includes hundreds of tips on how to save time, money, and effort in the home studio.



How To Build A Small Budget Recording Studio From Scratch, Third Edition

by Mike Shea
McGraw-Hill
2 Penn Plaza, 12th Floor
New York, NY 10121
800-2MCGRAW
www.books.mcgraw-hill.com
$24.95

Planning to build or remodel a recording studio on a budget? This reference will guide you through building an efficient, fully-functional studio–with no special training or knowledge of acoustics needed. It provides 12 tested and proven recording designs, valuable information on acoustical materials, the latest in computer-controlled audio test equipment, and new techniques used to isolate and control vibration.

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For more information go to page 80A

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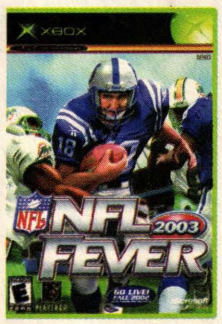
High-Tech Paper

The innovative *e-Reader* ($39.95) turns paper trading cards into electronic games. By connecting to the Game Boy Advance via the cartridge slot, it uses dot-code technology to read optical data imprinted on the card. When slid through the e-Reader, the trading cards allow players to experience games in a number of ways—the e-Reader cards hold complete video games playable on Game Boy Advance, enhance game play on Nintendo GameCube, and expand play of the traditional trading card games.

Nintendo, 4820 150th Ave. N.E., Redmond, WA 98052; 800-255-3700; *www.nintendo.com*.

CIRCLE 50 ON FREE INFORMATION CARD

Ultimate Game Play



Easy to pick up and play, *NFL Fever 2003* ($49.99) for the Xbox video game system delivers all the action and excitement of real football. Gamers can create, play, and control the "perfect" football team, with highly-detailed player models that reflect the size and physique of real professional players. The momentum-based motions provide realistic animation, while the dynamic lighting, dramatic shadows, and play-by-play commentary add to the "real" experience.

Microsoft, 825 Eighth Ave., New York, NY 10019; 212-245-2100; *www.xbox.com*.

CIRCLE 52 ON FREE INFORMATION CARD

Dynamic Performance

Delivering a full complement of bass clarity, midrange definition, and treble clarity and extension, the *Signature 805 Loudspeaker* $(1750) is a widely-accepted standard for high-end audio and home-theater systems. Advancements include a more powerful bass driver, a tweeter with extended response, and improved bottom-end detail. The exterior is a hand-rubbed grey or red veneer.

B & W Loudspeakers of America, 54 Concord St., North Reading, MA 01864-2699; 800-370-3740 or 978-664-2870; *www.bwspeakers.com*.

CIRCLE 51 ON FREE INFORMATION CARD

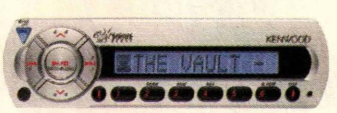
Everything But The Popcorn

This unique and attractive *Home-Theater-In-A-Box DHT-1000DV* ($1199) promises everything you need for an ultimate movie experience—except the snacks. It features a high-performance combination DVD-player/audio-visual receiver, a center-channel speaker, four satellite speakers, and a subwoofer.

Denon Electronics, 19 Chapin Rd., P.O. Box 867, Pine Brook, NJ 07058-9777; 973-396-0810; *www.denon.com*.

CIRCLE 53 ON FREE INFORMATION CARD

Satellite Radio



Music lovers can enjoy commercial-free jazz, bluegrass, classic rock, contemporary, classical, and more, with the *Kenwood Music Keg Satellite Radio System SSR-FM!* ($229.95) featuring the *Sirius Satellite Radio Broadcaster* ($12.95/month). The hardware unit connects to most car audio systems through the FM tuner, and allows users to access 100 channels of music, news, sports, and entertainment nationwide via satellite.

Sirius Satellite Radio Inc., 1221 Avenue of the Americas, New York, NY 10020; 212-584-5100; *www.sirius.com*.

CIRCLE 54 ON FREE INFORMATION CARD

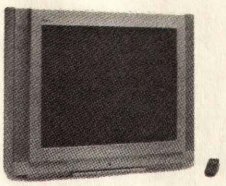
The Best Of Everything

Thanks to its universal format capability, audiophiles no longer have to choose between a DVD-Audio or SACD—the *DV8300 Combination Player* ($1499.99) has it all. Along with two-channel and multi-channel DVD-audio capability, the player offers compatible playback of DVD-video, CD, CD-R/RW, MP3, video CD, and super-video CD discs. In addition, it includes built-in Dolby Digital and DTS surround-sound decoding, and a full selection of digital and analog audio and video outputs.

Marantz America, Inc., 1100 Maplewood Dr., Itasca, IL 60143; 630-741-0300; *www.marantz.com.*

CIRCLE 55 ON FREE INFORMATION CARD

True Colors



Able to deliver true digital-TV images from any source, the *32-Inch HT-34A ProFlat High Definition Direct-View Monitor/NTSC Receiver* ($3000) boasts super-fine aperture-video processing and advanced fine-scanning modulation for a crisp image and concentrated picture detail. It also features a built-in, six-speaker, three-way system with two tweeters, two midrange speakers, and dual subwoofers, along with a Spatializer 3D sound system.

Proton Corp., 13073 East 166 St., Cerritos, CA 90703-2201; 562-404-2222; *www.proton-usa.com.*

CIRCLE 57 ON FREE INFORMATION CARD

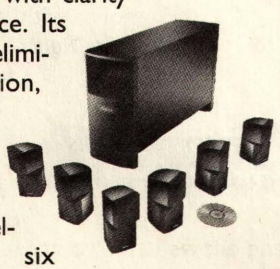
Easy On The Ears

Do you love to sing, but afraid you are tone deaf? The *On-Key Karaoke Player* ($79) offers a solution to the tonally challenged—the system can alter the singer's voice to match the pitch of the original recording. All of the electronics and the music are built in to the microphone, so all the singer has to do is connect it to a TV, where song lyrics and background images will appear on the screen. The sound is played through the TV's speakers or the audio portion of a stereo system for better quality.

IVL Technologies, 6710 Bertram Place, Victoria, BC, Canada V8M 1Z6; 250-544-4091; *www.ivl.com.*

CIRCLE 56 ON FREE INFORMATION CARD

Sound Solution

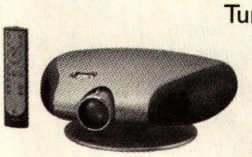


Whether it's the roar of a train or a classical melody, the *Acoustimass 16 Speaker System* ($1498) delivers sound with clarity and life-like performance. Its patented technology eliminates audible distortion, faithfully reproducing speech, music, and other sounds. The system includes a center-surround channel-speaker array with six direct/reflecting cube speakers, three 5¼-inch high-excursion woofers, and proprietary signal-processing.

Bose Corp., The Mountain, Framingham, MA 01701; 508-879-7330; *www.bose.com.*

CIRCLE 58 ON FREE NFORMATION CARD

Cutting-Edge Cinema



Turn your family room into a true movie theater with the *DT-200 Home-Theater Projector* ($3499.95). Weighing just over 7½ pounds, the DT-200 is engineered to provide high-resolution imagery, ultra-high contrast ration, and convenient installation. It also features a short-throw lens requiring minimal set-up space, and 2D-keystone correction that enables the user to position the projector almost anywhere without picture distortion.

Sharp Electronics Corp., Sharp Plaza, Mahwah, NJ 07430; 201-529-9620; *www.sharpelectronics.com.*

CIRCLE 59 ON FREE INFORMATION CARD

Go "Live"

Communicate on-the-go with the *Mobile Connect Web Camera* ($79.99). Its high resolution promises quality digital photos and video clips, and users can send video messages to family and friends virtually anywhere. The camera's small design allows for easy transport. Included in the package is a brushed-aluminum travel case, mobile-connect CD-ROM, an 18-inch USB cable, and an easy-to-follow user's guide.

Veo, *www.veo.com*.

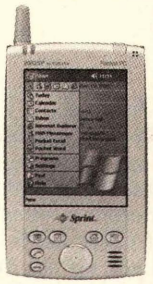
Cyber Shot

Featuring a 4.0-megapixel resolution and 3X-optical zoom, the *DSC-P9 Cyber-shot Digital Still Camera* ($599.95) is ultra-compact, weighing in at 7.5 ounces. The camera also boasts 3-area multi-point auto focus, multi-pattern metering, Memory Stick media recording, and 3 MPEG movie modes with audio. A rechargeable battery, AC adapter/in-camera charger, and A/V and USB cables, are all included.

SONY, *www.sony.com*.

Mobile Companions

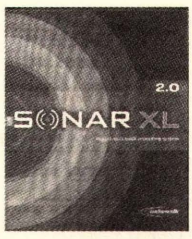
Sleek and compact, the *Thera Pocket PC* ($999) can transform any place into a virtual office by enabling high-speed wireless Internet access, wireless voice communications, and other Windows applications. This user-friendly pocket pal integrates CDMA2000 1X wireless voice and data capabilities, and is powered by an Intel Strong ARM 206-MHz processor. The size of a 3 × 5 index card, the device boasts full-color displays and features a built-in voice recorder, headphone jack, and a touch-screen with handwriting recognition, as well as an on-screen keyboard.



Audiovox Communications Corp., *www.audiovox.com*.

Limitless Power

Offering speed, precision, and stability, *Sonar XL 2.0* ($739) provides a complete software-based music production environment with unlimited creative potential. With support for real-time effects, soft synths, and hardware controllers, *Sonar XL 2.0* integrates multi-track recording, editing, mixing and delivery of audio and MIDI. Other highlights include 24-bit/96-kHz audio hardware support, internal MIDI precision of 960 PPQN, unlimited undo/redo, and endless mixing capabiblities.



Cakewalk, *www.cakewalk.com*.

Brilliant Display

Designed to accommodate a wide range of users, the *Ultra Sharp 1504FP 15-Inch Flat Panel Color Monitor* ($449) displays sharp images of text and graphics with a maximum resolution of up to 1024 x 768 pixels. Its wide viewing angle allows users to view the screen from various positions without compromising picture quality. Fast response times provide superior clarity for moving images, while a high-contrast ratio and premium brightness generate crisp, richer images.

Dell, *www.dell.com*.

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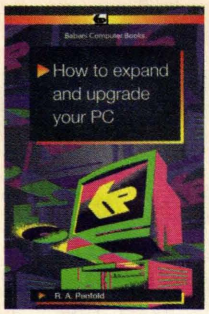


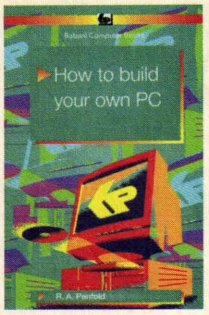
BP 450—$12.99
How to expand and upgrade your PC

This book provides advice and guidance on the popular forms of internal PC expansion, and should help to make things reasonably straight forward and hopefully painless! The book covers such topics as memory upgrades; adding hard and floppy disc drives; display adaptors and monitors; ports; keyboards; mice and graphic tablets; DIY PCs, etc.

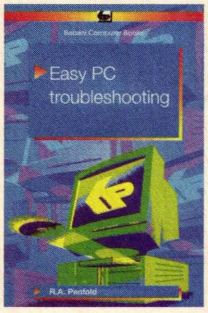
☑ Beginners ☑ Intermediate ☑ Advanced

BP 479—$12.99
How to build your own PC

Takes the reader through the process of assembling a PC from freely available and relatively inexpensive component parts. Topics covered include: buying the right components, simple anti-static precautions, configuring the motherboard, fitting the processor and memory modules, mechanical assembly and cabling, and more.



☑ Beginners ☑ Intermediate ☐ Advanced



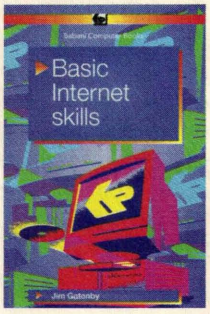
BP 484—$12.99
Easy PC troubleshooting

If you have some knowledge of PCs and take a logical approach, then with the help of this book, many faults can be identified and then rectified quickly and easily. This book shows you how to: test various parts of the system, diagnose a wide range of faults, check cables and connections, deal with the BIOS, and more.

☑ Beginners ☑ Intermediate ☑ Advanced

BP 494—$12.99
Basic Internet skills

This book is intended to help you make maximum use of the Internet. It concentrates on the core skills needed to fully exploit three of the main Internet features: electronic mail, searching for information using a Web browser and creating and publishing your own Web site. Practice exercises and self-assessment checklists are included throughout the book.



☑ Beginners ☑ Intermediate ☐ Advanced

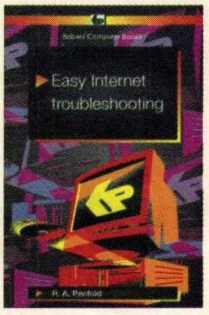
BP 501—$12.99
XHTML and CSS explained

If you know HTML, then you already know 85% of XHTML. This text will teach you how to create Web pages using the new language. XHTML uses Cascading Style Sheets (CSS) as the presentation language to format the content. Consequently, much of this text explains how to create and use style sheets.

☑ Beginners ☑ Intermediate ☑ Advanced

BP 507—$12.99
Easy Internet troubleshooting

With the aid of this book you can tackle all sorts of problems related to the Internet. Virtually every aspect of using the Internet is covered and you do not have to be a computer expert to follow most of the procedures. All you need to have is a very basic understanding of the Windows operating system.



☑ Beginners ☑ Intermediate ☑ Advanced

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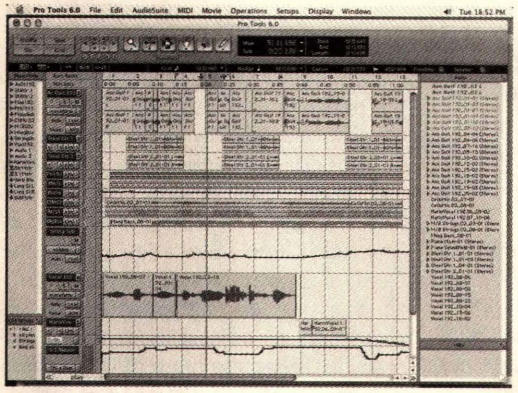


PRO TOOLS 6.0

For those of you into electronic-music recording via the computer, DigiDesign is premiering their latest version of *Pro Tools* for the Mac. *Pro Tools* 6.0 has added a powerful set of new features and improvements.

First and foremost, the package promises improved organization. Usually, in the past, the larger your Pro Tools session, the more difficult it was to navigate around all the elements it contained. Media files could be located on different drives, both internal and external; and if you're working on multiple projects with different media sources (external drives, effects CDs, etc.), there's a good possibility of confusion.

Pro Tools 6.0 now includes a new file-management utility called DigiBase to help you keep it all straight. DigiBase is similar to Mac's Finder or Windows' Explorer, as it lets you manage all of the files on your system. Moreover, DigiBase allows you to view complete file information including duration, timestamps, and two user comments fields. Display layouts can be customized so you can focus on just the information you need.

Another enhancement is that you can audition files and view their waveform thumbnails before importing into Pro Tools, regardless of file format or sample rate. When you've decided on a selection, the one-step drag-and-drop process from DigiBase to your session timeline includes automatic file copy and conversion, guaranteeing compatibility with your project. Also, *Pro Tools 6.0* handles many tasks such as copying, conversion, and fade creation in the background so that you can continue to record and edit without interruption. A new Task Manager feature enables users to monitor and manage background processes.

Pro Tools 6.0 incorporates enhanced MIDI functionality, including full support for Mac OS X's Core MIDI Services. MIDI Time Stamping (MTS) support provides sample-accurate MIDI with Pro Tools-compatible software synths and samplers, eliminating the possibility of compromised sync and drift issues. Also, you can take advantage of up to sub-millisecond-accurate MIDI with Digidesign's MIDI I/O and other supported MTS-capable interfaces.

The new MIDI capabilities allow extensive manipulation of rhythmic content through powerful groove creation and modification tools. The Groove Quantize feature incorporates intelligent Bar|Beat adjustment as well as support for the new 960-ppq DigiGroove templates.

With Pro Tools' Beat Detective tool you are able to extract and generate DigiGroove templates based on audio performances and utilize both the timing and the dynamics of passages elsewhere in your composition. These DigiGroove templates are also compatible with new Feel Injector templates from Numerical Sound.

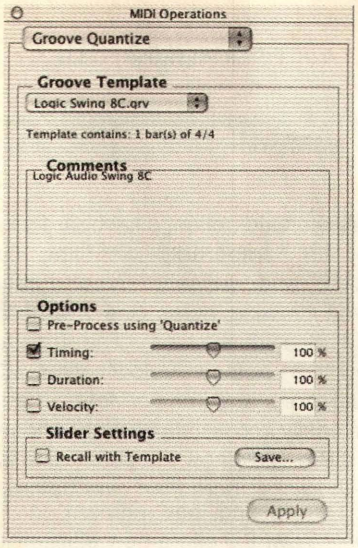
The software's MIDI implementation features a new Restore Performance function, enabling you to return to an original MIDI-based performance at any time. This feature lets you experiment with the assurance that you can always recover from any changes made during the course of your project. When you are finished arranging, the Flatten Performance feature solidifies any edits and gives you a new, permanent basis from which to proceed.

Additional new features include a Relative Grid option, a keyboard shortcut for temporarily disabling Grid mode, and definable note duration when drawing notes (the Pencil tool now also trims notes). The Trim tool now trims notes in Velocity view, MIDI Operations and Tempo/Meter Change are easily accessible floating windows, and Pro Tools now supports up to 256 MIDI tracks, more than ever before.

The mixing environment in *Pro Tools TDM 6.0* offers new efficiencies, and among those is the ability to import any track attributes from one session into another (TDM systems only). You can choose to import any combination of track data including audio playlists, MIDI playlists, mixer automation, routing assignments, plug-in instances and settings, and plug-in automation. Plus, you can choose to replace or overlay the data in relation to your existing session.

MachineControl option enhancements (TDM only) are also included in *Pro Tools 6.0*, allowing an even higher degree of streamlining the workflow. A new Machine Profile utility enables you to create deck configuration profiles for controlling any Sony 9-pin controllable deck, and includes support for custom track name entry in each deck profile, for even easier operation when remotely track arming. 9-pin deck emulation operation now includes a "Remote LTC Mode" allowing you to chase LTC while receiving 9-pin record and track-arming commands. The result: support for higher track counts and faster operation when in deck emulation mode. You are also able to generate timecode while emulating a 9-pin deck.

Lastly, a new Offset setting for MachineControl, chasing timecode, and MMC enables you to compensate for minor differences in source tape versions. You can create a single session with multiple VOs and then quickly offset Pro Tools compared to the tape for each layback performed. Additionally, the Set Timecode Position function allows you to select a location in your timeline and re-enter its timecode position, relatively resetting the entire timeline.



ProTools 6.0 includes many new MIDI capabilities.

THE SPIN ON PLASTIC

What do you get when you combine the quantum theory behind spintronics and plastic magnets? You get a fast, inexpensive computer that responds instantly and offers ultimate protection against crashes. Spintronics, or spin electronics, is the study of the role played by the electron's spin in solid-state physics, and devices that could specifically exploit spin properties. Spintronics technology has actually been around for several years. However, there is still much research to be done, and it holds a lot of promise.

The real news here is the use of plastic incorporated in spintronics technology. Arthur Epstein, a professor of physics and chemistry at Ohio State University, and his colleagues reported the use of a magnetic field to make nearly all the moving electrons inside a sample of plastic spin in the same direction. This is an effect called spin polarization, and it is the first step in converting the plastic into a device that could read and write spintronic data inside a working computer.

"It's another level of function that opens up a whole new way of doing circuitry," said Epstein. "On a regular desktop it can take several seconds or longer to boot up because it has to retrieve, out of the magnetic memory, information for the computer's settings and then put it onto the RAM. A spintronic-based computer would boot up instantly because, with a magnetic control drive, the information would be stored right in the RAM."

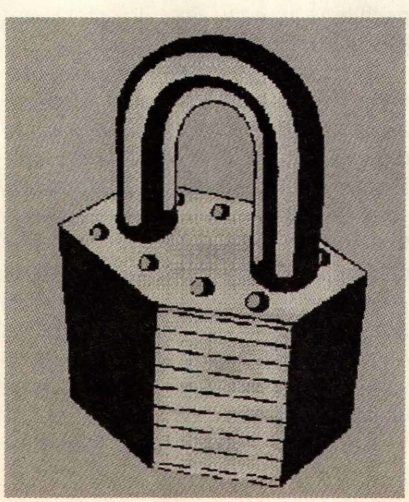
Why the big deal about spintronics? Here are just a few reasons why many researchers are excited about this technology:

- Presently, normal electronics encode computer information based on a binary code of ones and zeros. With spintronics technology, the direction of a spinning electron, either "spin up" or "spin down," could be used as data also. This would enable computers to store and move twice as much data per electron.
- Data could be stored permanently without the risk of being lost due to a computer crash.
- Complex Information would be instantly available at any time. In today's computers each bit of information in a silicon chip consists of thousands of electrons. With spintronics technology, one bit can be reduced to only one electron. The direction of the electron's spin would determine whether it's a one or a zero.
- Plastic spintronics would weigh and cost less than traditional electronics.

There's a lot of information out there on current issues and trends in spintronics. The U.S. Dept. of Defense recently spent millions of dollars on spintronics research, so it's obviously a hot topic. We'll cover it again in upcoming issues, and maybe go into a little more depth on exactly how it works. For now, see the illustration for details.

SECRECY OR SECURITY?

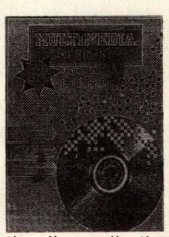
Due to heightened threat levels, the United States government has taken vast measures to tighten security within its borders–both physically and virtually. The question, however, is this: Is the secrecy of important information helping or hindering our safety and security?



Back in January of last year, government officials issued a "confidential memo" to all agencies regarding sensitive information. Agencies were instructed to restrict certain sensitive information, making it unavailable to the public on the Internet, except what was required by law to be accessible.

Among the agencies to comply were the Agency for Toxic Substances and Disease Registry, the Bureau of Transportation Statistics, and the Dept. of Energy. Now, the general public was probably not affected by this restriction, as most citizens aren't normally in desperate need of international nuclear safety information or reports from the Los Alamos National Lab.

However, researchers and scientists are also being barred from a lot of information necessary to their studies and experiments. They fear that this effort to protect national security could, in essence, hurt the public. For instance, researchers at the University of Michigan are in the middle of a three-year study of hazardous waste and its effect on humans and the environment; but they have been denied access to some vital databases needed to conclude their research. P



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MA02

YESTERDAY'S NEWS

A PEEK INTO THE GERNSBACK ARCHIVES

1900

1910

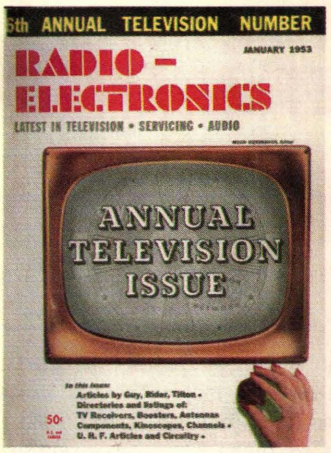
1930

1940

1953

Dateline: January 1953 (50 years ago)

This is **Radio Electronics'** 6th Annual Television Issue, featuring an editorial on new developments in television and its impact on radio broadcasting. Hugo Gernsback reports "the first closed-circuit telecast of the Metropolitan opera is about to be shown in a number of theaters in the U.S." Some other trends in the television industry: 21-inch sets are priced under $200 for the first time, technological advancements are paving the way for color TV, and magnetic tape could soon be used to record television programs.



1960

1973

Dateline: January 1973 (30 years ago)

Read about the latest in color-television technology in this Special Color TV Issue of **Radio Electronics**. Articles discuss new circuits, automatic color controls, color test jigs, and AFPC detectors. Future predictions include wall-sized pictures with projection screens and frame snatchers that capture and hold a single-picture frame. The "Equipment Report" introduces the B&K model 501A transistor curve tracer, the newest lab instrument to turn up on the service bench.

1980

Dateline: January 1993 (10 years ago)

Popular Electronics explores the technology behind on-board navigation systems for your car, including satellite positioning, roadside beacons, and other advancements. Construction articles feature building an aviation receiver, a dog-bark inhibitor, and a telephone line-in-use indicator. Also, learn all about microprocessors and makes these powerful chips tick; and the history of code and code-sending gear from the early days to present-day computerized equipment.

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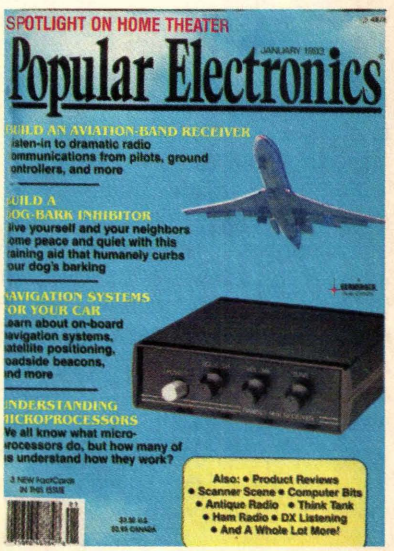
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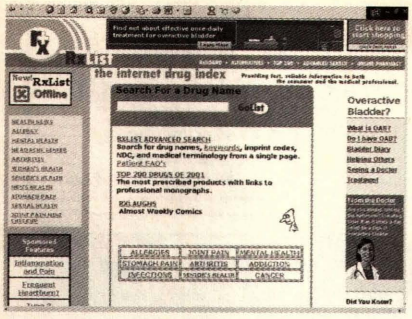
Sometimes you want to know in detail how something works. The appropriately named site HowStuffWorks, at *www.howstuffworks.com,* provides descriptions, diagrams, and photos of more than 2,500 devices and processes in categories from automotive and electronics to health and money.

If it's a statistic you need, check out Statistics.com, at *www.statistics.com.* You'll find numbers from government and other sources on a range of different topics, though you'll be more likely to find regularly-published data there than private-market research. Another good site is the University of Michigan's Statistical Resources on the Web, at *www.lib.umich.edu/govdocs/stats.html.*

Two excellent sites for checking general health information are Harvard University-affiliated InteliHealth, at



RxList (www.rxlist.com) *provides information about brand name and generic pharmaceutical drugs, as does the National Library of Medicine's Medicine Plus Drug Information* (www.nlm.nih.gov/medlineplus/druginformation.html).

www.mayoclinic.com. RxList, at *www.rxlist.com,* and the National Library of Medicine's Medline Plus Drug Information, at *www.nlm.nih.gov/medlineplus/druginformation.html,* both provide information about brand name and generic pharmaceutical drugs.

A number of sites compile links of reference materials. The best overall is the University of Michigan's Internet Public Library, at *www.ipl.org.* There you'll find links to almanacs, calendars, dictionaries, style and writing guides, quotations, biographies, encyclopedias, atlases, books, magazines, and newspapers, among other materials.

Another good general reference site is Researchville, at *www.researchville.com.* It conveniently lets you do "meta searching" of multiple sources at once with just a single query, though it doesn't combine results on a single page. You can search multiple almanacs, encyclopedias, dictionaries, newspapers, newswires, magazines, health sources, education sources, government sources, and discussion forums.

Finally, you might think that UselessKnowledge.com, at *www.uselessknowledge.com*, is fairly useless; but this whimsically named site is a great trivia resource, letting you among other things search for arcane information by keyword.

SOME USEFUL KNOWLEDGE

Let's take a look at a specific research challenge: What to do with your old clunker of a PC. You've gotten good use out of your computer, putting it through its paces. It has cranked out words, crunched numbers, and cruised through cyberspace. Now it's getting long in the tooth and slowing you down. Time to upgrade to a new machine—but what should you do with your old warhorse?

This was the dilemma that Steven Cohen of Blue Bell, Pa., faced recently. He had just bought a spanking new Dell Dimension Pentium 4, and he didn't want to just trash his old AST Pentium. So he asked around and learned of a couple of Web sites that described other options—PEP Computer Recycling at *www.microweb.com/pepsite/Recycle/recycle_index.html* and UsedComputer.com at *www.usedcomputer.com/nonprof.html.*

He wound up e-mailing the United Way. "I wanted to donate it to a good cause," says Cohen, a recent retiree who used his home computer for work projects, keeping track of personal finances, letter writing, and connecting to AOL. "It seemed to me that since this computer helped me, it could also help someone else, maybe a senior citizen or school who couldn't afford a new computer."

Cohen's e-mail message was forwarded to the United Way office closest to him, and the United Way's Steve Rockwell e-mailed him back, asking about the computer's specifications. Then Rockwell gave Cohen an address near him where he could drop off his machine. Individuals have to drop off donated machines themselves, but organizations with ten or more machines to donate can have them picked up.

Rockwell heads up the local United Way's Teaming for Technology program, which is similar to other computer recycling programs around the country. Working with other organizations, the United Way places donated computers with local non-profits, at community technology centers for people

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who can't afford home computers, and in the homes of low-income people.

But first it refurbishes old systems, utilizing at-risk youth and welfare-to-work adults, who pick up job skills in the process. Computer professionals provide training and do quality control. Low-income individuals can obtain free refurbished PCs for their homes, but they first have to go through a training program to ensure they'll be able to properly use the machines.

Like similar programs, the United Way's program can't use all PCs. It prefers newer computers, those with Pentium II or faster chips, though it will accept 166-MHz or faster Pentium I machines.

If you have an even older machine, say a 486, you still don't have to consign it to a landfill. If it's still working, you can hand it down to a family member, relative, or friend. Some companies regularly shuffle computers this way, buying new and more powerful machines for those who do processor-intensive work such as computer-aided design or video editing and upgrading other employees with the computers that are handed down.

CASHING IN

You can also sell your used computer. Some computer stores specialize in handling used machines—check your local Yellow Pages. The advantage here is that you can simply take your computer to the store instead of having to deal with and ship to a buyer directly.

You'll usually get a bigger bang for you buck by selling the machine directly to another individual. You can buy a classified ad in your local newspaper, or you can use the Internet.

Lots of used PCs deals take place through Web sites such as Half.com at *http://half.ebay.com.* Still others take place through Usenet discussion boards such as *misc.forsale.computers.pc-specific.systems*, if you're selling a PC, and *misc.forsale.computers.mac-specific.systems*, if you're selling a Mac.

To minimize the risks involved in buying and selling over the Internet, it can make sense to send the system COD (cash on delivery), recommends Daniel King, who put together a "Frequently Asked Questions" archive about buying and selling on the Internet.

One further option is to have your old computer "de-manufactured." The process involves first salvaging usable parts, such as monitors and hard drives, then isolating from the rest metals such as copper, aluminum, steel, stainless steel, nickel, and brass. In a landfill, these and other substances can potentially leech into soil and groundwater.

There are many companies that recycle old computers this way. Check out the Web site Computer Demanufacturing Suppliers at *www.powersourcing.com/se/computerdemanufacturing.htm* to find one near you.

Some companies charge small fees to take a computer or computers off your hands even if you deliver it yourself, which they say are needed to recoup the costs of sending components out to be de-manufactured. States such as Delaware provide funding to eliminate these computer recycling fees.

Reid Goldsborough is a syndicated columnist and author of the book *Straight Talk About the Information Superhighway*. He can be reached at reidgold@netaxs.com or *www.netaxs.com/~reidgold/column.* P

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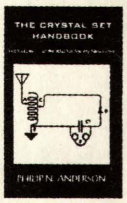

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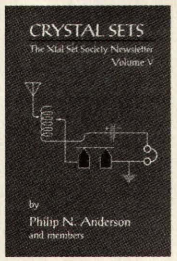

Volume V of the Society newsletter includes six issues ending November 1995. Great for new members to get current, those wanting a bound copy for their reference bookshelf, or as a gift to get a friend started. Contents include: The Design of Unpowered AM Receivers, Radio Outfit in a Headset, A Crystal Set Revisited-Reconstructed, Grounded Loop-stick Tuner, The Matching Secret, and lots of membership correspondence. 8½ × 5½ paperback, **$10.95 plus shipping.—Electronic Technology Today Inc., PO Box 240, Massapequa Park, NY 11762-0240.** US funds only. Allow 6-8 weeks for delivery. MA06

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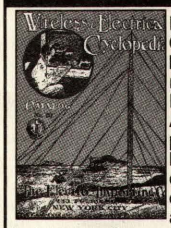

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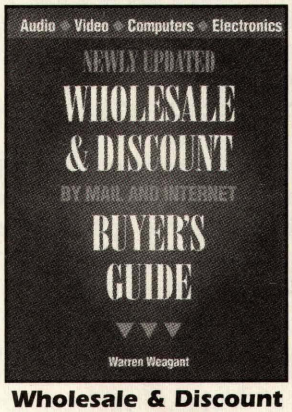

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Modulation Methods—Frequency Modulation

The use of *f*requency *m*odulation (called FM) is another method of adding intelligence to a carrier signal. While simple on-off keying (as used in Morse Code) and amplitude modulation were the first methods used to modulate a carrier, the use of FM had to await the availability of stable RF sources with a narrow-frequency spectrum. The vacuum-tube oscillator was the first RF source that could be frequency modulated. FM broadcasting started out before World War II as a means of obtaining "staticless" radio transmissions and better audio fidelity. Early FM broadcast stations used the 42–50-MHz band for their FM transmissions.

At that time, 42-50 MHz was considered ultra-high frequency. The elimination of amplitude modulation enabled the receiver to utilize high gain, so as to deliberately overload the amplifier stages in the IF circuitry, which had the effect of limiting (clipping) the received signal amplitude. This effectively suppressed AM-noise spikes, and FM-detector circuits could be also designed to reject AM signals to some degree.

The fact that much man-made noise is AM in nature, and that natural atmospheric-static levels are lower at 42 MHz than at AM-broadcast frequencies, allowed very quiet reception with little if any static. Also, it was feasible to transmit a wider band of audio frequencies as larger amounts of spectrum space allowed wider signal bandwidths. Additionally, the bandwidth limitations of modulation transformers used in AM transmitters at the time could be circumvented.

A number of FM receivers were made for 42-50 MHz, and some surviving sets can still be found in forgotten attics and in antique-radio collections. However, after WWII, the FM band was relocated to its present location at 88-108 MHz. There is still some FM broadcasting around 68 MHz in the former Soviet Union, and additionally, 76-88 MHz is also used in the Far East. Narrow band (±5-kHz deviation) FM is also widely used for TV audio and for 2-way VHF and UHF communications.

FM Signals

An FM signal is simply any RF signal that is modulated by changing the frequency of the signal in accordance with the modulation. Since frequency is measured in cycles per second (Hz), and cycles per second can be thought of as the number of times a sine wave goes through a complete cycle (0 to 360 degrees) in one second, one can consider frequency as the rate of change of phase (degrees) of a sinusoidal waveform per unit time (second)—mathematically speaking, dq/dt, or the rate of change of phase angle with respect to time. Similarly, the reverse relationship says that total phase change in a time period equals the frequency multiplied by time.

Frequency Modulation

Frequency modulation is therefore related to phase modulation. Phase modulation is that modulation in which the relative phase of a carrier wave, with respect to a reference, is varied in accordance with a modulating signal. In order to change the phase of a signal, there has to be an instantaneous change in frequency. As an example, if we want to change the phase of a carrier from 0 degrees to 180 degrees, we must "reverse" one cycle (See Fig. 1). This would involve raising or lowering the frequency for a very short instant so the relationship of the phase with respect to the original phase could change.

If we want to vary the frequency of a signal, the instantaneous phase of the signal must continuously change. For example, suppose we want to sweep from 100 MHz to 101 MHz in one second. This implies a frequency change of 1 MHz per second, (or 1 Hz per microsecond). In one microsecond, the 100-MHz carrier will go through 100 cycles. In this brief period, 1 cycle must be added so that after one second, one million cycles per second has been added. This can be done by advancing the phase of the carrier 1/100 cycle, or 3.6 degrees, every cycle, so that after 1 microsecond, 101 cycles will have been gone through, and the new instantaneous frequency will be 100,000,001 cycles (100 MHz + 1 Hz) per second.

Notice that a constant rate of change of phase has been introduced to produce a "sliding" frequency. If this rate of change of phase is kept up indefinitely, the frequency would continue to sweep upward by 1 MHz per second, so that at t=l second the carrier frequency would be 101 MHz, at t=2 seconds, 102 MHz, etc. If we retarded the phase by the same 3.6 degrees, we would have produced a decrease in frequency of 1 MHz per second (in this example). If you did not follow this, or cannot understand the concept, simply remember that a change in frequency implies a phase change, and vice versa.

The deviation of an FM signal is the component of change in carrier frequency that the modulating signal produces. Note that, in general, the frequency of the modulating signal is NOT the same, nor necessarily related, to the deviation. In the US, FM broadcast stations by law are permitted +75-kHz deviation, which is defined by the standards for FM broadcasting as 100% modulation. Both a 20-Hz audio signal and a 20-kHz audio signal can produce 75-kHz deviation. The amplitude of the modulating signal (program audio) produces the deviation. If one volt of audio produces

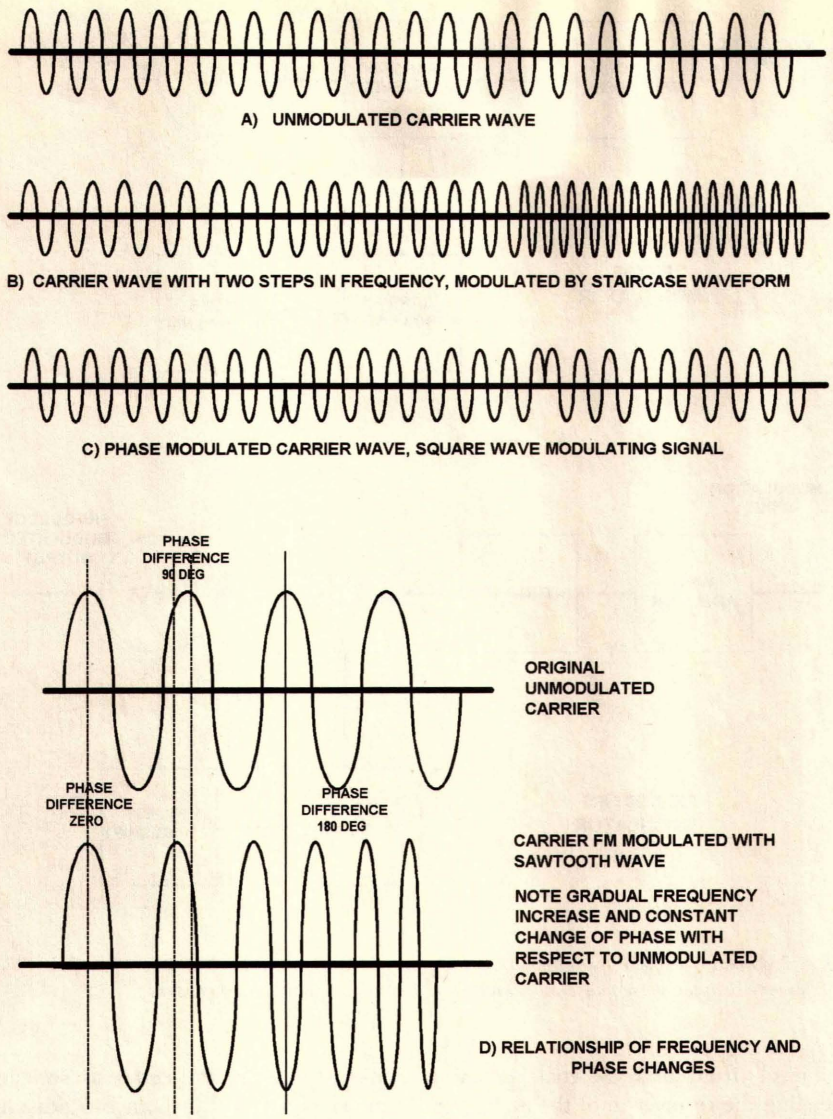
A) UNMODULATED CARRIER WAVE
B) CARRIER WAVE WITH TWO STEPS IN FREQUENCY, MODULATED BY STAIRCASE WAVEFORM
C) PHASE MODULATED CARRIER WAVE, SQUARE WAVE MODULATING SIGNAL
PHASE DIFFERENCE 90 DEG
ORIGINAL UNMODULATED CARRIER
PHASE DIFFERENCE ZERO
PHASE DIFFERENCE 180 DEG
CARRIER FM MODULATED WITH SAWTOOTH WAVE
NOTE GRADUAL FREQUENCY INCREASE AND CONSTANT CHANGE OF PHASE WITH RESPECT TO UNMODULATED CARRIER
D) RELATIONSHIP OF FREQUENCY AND PHASE CHANGES

Fig. 1. Here is a visual reference for studying the relationship between frequency- and phase-modulated waveforms. The original unmodulated carrier is a sinusoidal waveform.

+75-kHz deviation, then one-tenth of a volt would produce +7.5-kHz deviation. Deviation and modulation frequency are independent variables.

Deviations

Note that much wider deviations are possible. An AM transmitter has definite physical limits on modulation (over-modulation will cut off the carrier and clip on positive peaks as the modulator is power limited). An FM transmitter has no such kind of physical limits. The limit of modulation is set as that which results in excessive modulation non-linearity (instantaneous frequency vs. modulating voltage) in the modulation, or in how much frequency deviation the FM receiver will accept before it distorts the signal.

This is related to receiver bandwidth. There is no theoretical reason why our FM stations could not have used 100-kHz, or even 1-MHz deviation, other than needing more spectrum space. However, greater receiver sensitivity is possible with narrower bandwidths. Wider deviations are commonly used at microwave frequencies for data and video transmission. Satellite-television transmission uses 10- to 15-MHz deviation for the video signal, with a receiver bandwidth of 30- to 36-MHz.

The ratio of deviation to modulation frequency is called the modulation index. The Greek letter "b" (beta) is usually used to represent this quantity. It represents the maximum phase shift of the carrier wave.

$$\beta = \text{Deviation} / \text{Modulation frequency} = \text{Modulation Index}$$

Note that deviation and modulation frequency are in the same units of frequency (KHz, MHz, etc).

In general, the higher the value of β, the better the signal-to-noise ratio of an FM system compared to an AM system. In a typical FM broadcast-transmitter situation, with a 1-kHz audio signal at 50% modulation (37.5 kHz deviation):

$$\beta = \frac{37.5\ \text{KHz}}{1\ \text{kHz}} = 37.5$$

FM is often done by applying audio to a frequency-determining network component whose value is voltage dependent, such as a varactor diode. This is called Direct FM, since the frequency of the oscillator is being directly controlled by the modulating signal.

Related mathematically to FM is PM, or *p*hase *m*odulation. In this case the phase of the RF carrier is modulated by the applied-modulating signal. Phase modulation is generated by passing an RF signal through a phase-shift network whose characteristics are modulated by the modulating signal. It can also be generated indirectly using a balanced modulator and RF-carrier phase-shift networks (See Fig. 2). From this system, FM can be generated by simply integrating the modulating signal.

Modulating Signals

In practice, an R-C circuit can be used to integrate the modulating signal. It must be stated that this system is practically suitable for only small amounts of phase deviation, about 10-15 degrees of phase shift. (0.2 radians or so). Using this method to generate FM is called Indirect FM. To get practical amounts of deviation when indirect FM is to be used, a frequency multiplier usually is needed.

Often the degree of modulation requires a large multiplication factor. What is done here is that the signal is multiplied, mixed down to a much lower frequency, and multiplied up again. The deviation produced by the modulator is also multiplied by the multiplication factor, but unaffected by addition and subtraction. Therefore, if one starts out with a 1-MHz modulated signal, multiplies it by a factor of 64, then mixes the resultant 64-MHz signal down to 1 MHz again using a 63-MHz oscillator

and mixer, the new 1-MHz signal can be multiplied by say 96 to get 96 MHz, in the middle of the FM broadcast band, with an effective multiplication factor of $64 \times 96 = 6144$. This would allow a modulation index of 1228. This would allow full 75-kHz deviation with an audio-modulation frequency as low as 61 Hz, a situation that practically would seldom arise. One must start out with a high-quality and low-phase noise RF signal, as any FM noise on the original carrier would get multiplied by this 6144 factor as well.

Without going through the derivation, the signal-to-noise ratio improvement gained by using an FM system as compared to an AM system of the same bandwidth is related by the FM improvement factor:

$$S / N = 3\beta^2$$

This is valid as long as the FM system is operating above a threshold level which is typically 8- to 10-dB carrier-to-noise ratio. The receiver must have a certain minimum signal for this to happen. Otherwise the advantage of FM over AM is rapidly lost for weaker signals. For a typical 2-way FM-communications system with a 13-kHz bandwidth, the noise level (assuming a 3-dB receiver-noise figure) would be around –128 dBm, slightly less than 0.08 microvolts into 50 ohms.

The carrier level would have to be about 8 to 10 dB stronger, or about 0.2 microvolts to achieve threshold. This is a typical-rated sensitivity for many 2-way FM-communications receivers, such as used for public service and amateur FM. A stereo receiver with 250-kHz bandwidth would need a signal of about 1 microvolt at threshold, and you would probably not want to listen until the S/N ratio exceeded about 30-dB minimum. This increases rapidly above threshold, and about 2 microvolts or so would do.

Receivers are also specified in dB quieting, which is a measure of how much the receiver noise decreases on receipt of a carrier. This can be misleading as it does not take into account anything to do with the modulation. A measurement called SINAD (ratio of signal/(noise + distortion) is often used; and 12-dB SINAD, the often used standard ratio corresponds approximately to 20-dB quieting for many FM receivers in practice. This is done by adjusting the carrier level from an FM-signal generator feeding the receiver until the audio signal out of the receiver is 12 dB above the receiver output when the modulation at that carrier level is reduced to zero. This is about minimum signal level for reasonably intelligible speech output.

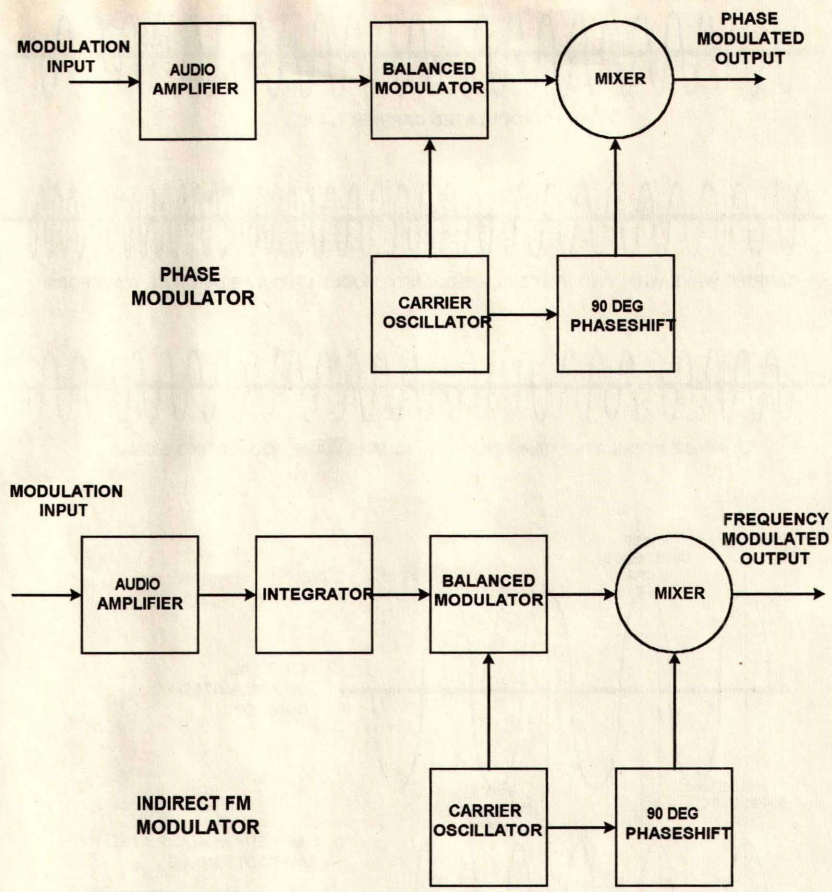

Fig. 2. Looking at these two block diagrams, notice that the integrator unit is what makes the difference between these phase-modulating and frequency-modulating networks.

Note that, for constant-modulation signal level, β increases at low-audio frequencies, and decreases at high-audio frequencies. Thus the signal-to-noise ratio of an FM system is poorer for high-audio frequencies than for low frequencies. This is the reason pre-emphasis is used in FM broadcasting, so as to boost the modulation index at the high end of the audio spectrum.

It turns out that, additionally, the noise spectrum of a detected output in an FM receiver has a rising noise vs. frequency characteristic. If we employ de-emphasis at the receiver, we not only correct for the pre-emphasis at the FM broadcast transmitter (which would make the audio sound "tinny"), but also pick up additional signal-to-noise improvement at the receiver as well. Pre-emphasis and de-emphasis are used in both broadcasting and commercial FM two-way radio (which usually uses +5 kHz deviation) to materially increase signal-to-noise ratio. This gives FM its excellent quality and "clean" sound. Since most static is AM in nature, very little static gets into the system. An FM receiver deliberately limits the incoming signal to a constant level before detection, further reducing AM-static rejection.

Bandwidth

The occupied bandwidth of an FM signal, at first glance, appears to be simply the peak-to-peak deviation. However, this is not generally true. A 75-kHz deviation FM-broadcast signal requires somewhat more bandwidth. It is necessary to know this required bandwidth for various reasons, among them channel spacing, necessary receiver bandwidth, and signal-to-noise ratio considerations.

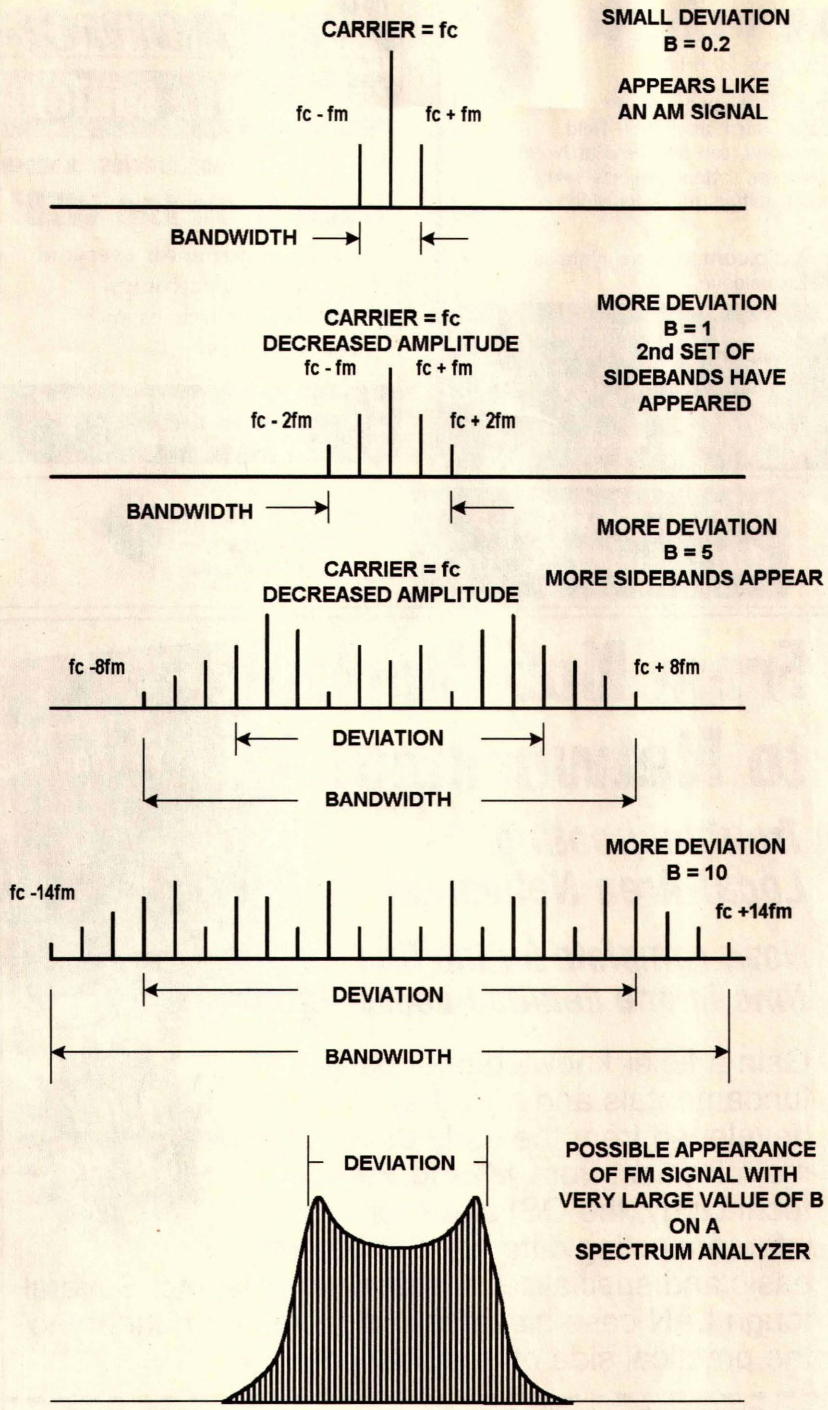

Fig. 3. There is a direct relationship between deviation and bandwidth, as shown by the diagrams above. Notice the indirect relationship between deviation and carrier amplitude.

For very high modulation indices, the necessary bandwidth is very close to the peak-to-peak deviation. As an example, this would be true for, say, a 100% modulated FM signal (75 kHz in commercial broadcasting) with a low-audio frequency modulation (i.e., 20 Hz). However, the situation changes for low-modulation indices. At a modulation index of 10 the bandwidth required would be about 2.8 times 75 kHz, or 210 kHz. At a modulation index of 5 (for example 15-kHz audio, with 75-kHz deviation) about 3.3 times 75 kHz, or 247 kHz bandwidth, would be required. (See Fig. 3).

This bandwidth change is due to the sidebands generated in FM. The sidebands, as in the AM case, are separated by the modulation frequency from the carrier. However, depending on the modulation index, the sidebands vary in amplitude. They appear, reach a maximum, then, at higher modulation indices, some sidebands disappear. In fact, the carrier disappears at a modulation index of 2.4. This means that if we apply a tone of about 31 kHz to an FM transmitter and adjust the level of this tone to produce a deviation of 75 kHz, the carrier will actually null out.

Of course, the FM signal has not disappeared. All of its energy is now contained in sidebands spaced 31 kHz from the carrier, at +31 kHz, +62 kHz, +93 kHz, etc. (This is somewhat like what happens in an SSB signal, where all the energy is in one sideband, with the carrier and other redundant sideband being suppressed.) As a matter of fact, the null of the carrier at a modulation index of 2.4 can be used to measure the deviation of an FM transmitter, using a spectrum analyzer. See Fig. 3 for a typical FM-signal spectrum.

The sidebands vary in amplitude in a pattern that can be expressed mathematically by Bessel functions of the first kind. A given sideband N, where N is the order (carrier N=0, first sidebands N=l, second N=2 etc.) of the Bessel function. We will not discuss this further, except to state that Fig. 3 is an approximate illustration of how these functions appear. Further discussion would require the reader to have a background in analytic geometry and integral calculus. We cannot assume this, and instead refer the interested reader to a more advanced text on modulation theory.

As a rule of thumb that works out in practice, the required bandwidth is approximately twice the deviation plus the highest modulating frequency. This figures out to about 240 kHz for an FM-Stereo receiver, and bandwidths of 230 to 280 kHz are used in practice. Note that the FM detector must be very linear over this bandwidth to reduce distortion on the recovered audio and to maintain good stereo separation. As another example, commercial 2-way FM radio used for police, fire, taxicab, etc., and also 2-meter amateur radio FM, use ±5-kHz deviation with audio restricted to 3 kHz (3000 Hz). These receivers use 12- to 13-kHz bandwidth IF filters. This is twice the deviation plus the highest modulation frequency, as is seen from the figures given. The various components of

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an FM-broadcast (stereo) signal are as follows:

A. Audio baseband 0-15 kHz. This is comprised of the sum of left and right audio channels, and is the basic program audio a monophonic FM radio would receive.

B. Stereo baseband (19 kHz and 23-53 kHz). This consists of a pilot carrier at 19 kHz, and a DSB (double sideband) suppressed carrier AM signal centered at 38 kHz. The 38-kHz carrier is suppressed, and a low-level pilot carrier at 19 kHz is used to regenerate the 38-kHz suppressed carrier. In this way the 38-kHz DSB AM signal is recovered and detected. It has the difference of left and right channel audio. This difference signal is zero for mono transmission.

C. SCA and RDS subcarriers at 57, 67, and 92 kHz with up to 7.5-kHz deviation.

Adding this up, twice the deviation plus the highest modulating frequency would be twice 75-kHz plus 92 ± 7.5 kHz, or about 250 kHz.

We have tried to present some of the basics of FM without going into the mathematics behind it. For more information on FM theory and practice, the reader should consult a good textbook on communications, and be prepared to go into the mathematics behind it all. P

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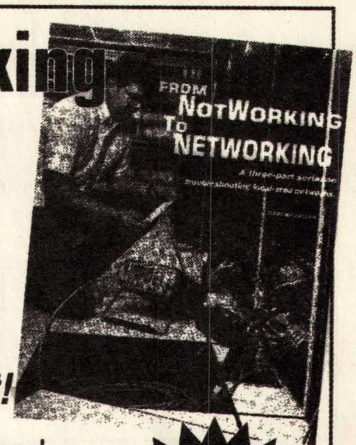

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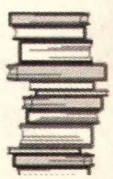

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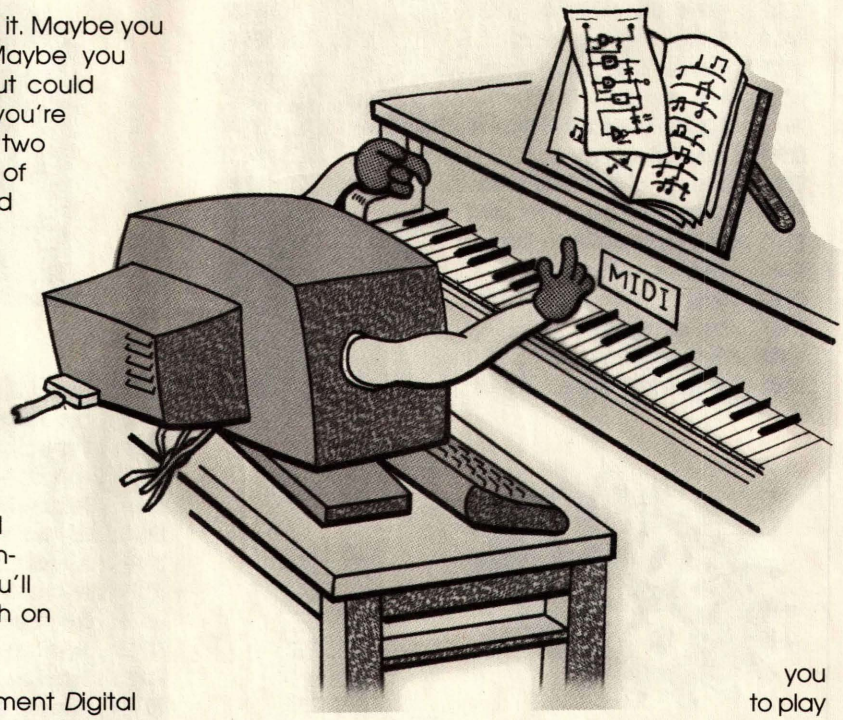
An Intro to MIDI

WILL ROMANO

MIDI. You may have heard about it. Maybe you even heard it being used. Maybe you even know a little about it, but could never figure out how it works. Relax—you're not alone. For the better part of the last two decades, MIDI has been a great source of both joy and frustration to "techies" and professional musicians alike.

Though MIDI has come a long way from its clunky beginnings, the basic laws remain intact. Even in today's hi-tech digital world, MIDI can be used in any number of applications. With this in mind, we thought we'd give a general overview of the basics of MIDI—what MIDI does, and how it is used.

When reading this piece, bear in mind that this is only an introduction to the principles and concepts of MIDI. You'll undoubtedly have to do more research on your own.



Is MIDI Magic? MIDI, or *M*usical *I*nstrument *D*igital *I*nterface, can literally let you hear music played by musicians who are not present. MIDI can make lights flicker while the road crew is sleeping backstage. Sounds like magic, doesn't it? In a way, it is.

In the early 80s, MIDI was designed and developed by a few major musical instrument manufacturers that saw a way for musicians to control sound from a remote location, giving performers the power to play one keyboard and have others ring out with similar or different sounds. Why is this important? Think of the economics and ergonomics of a live stage show. You could have just a handful of people doing the job of a full orchestra.

A common MIDI misconception is that MIDI is a sound medium in and of itself. It isn't. MIDI relates digital data regarding one snippet, one patch of sound, from one place to another. That patch or sample eventually manifests in a tone or noise.

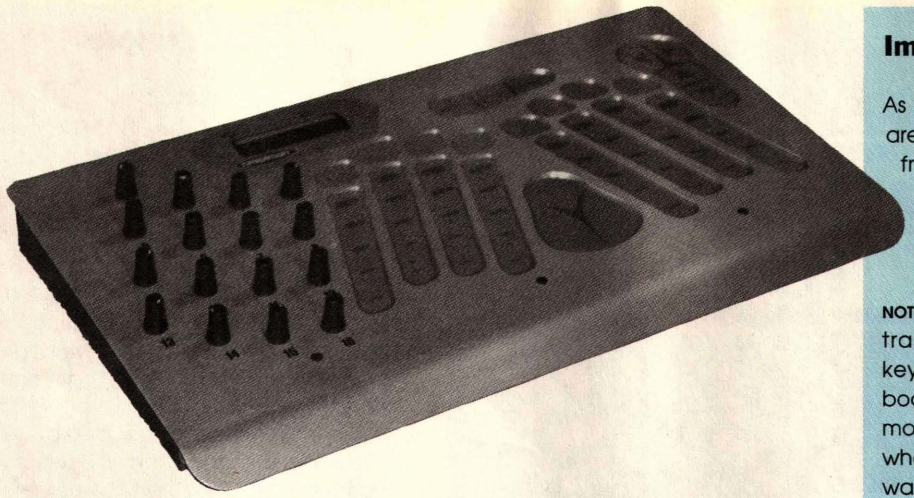
Think of MIDI this way. You get a signal coming into your cable box, which is then translated into an image on your TV screen. MIDI, in a way, is the medium through which the signal on your TV is being transmitted; it is not the image you see on your screen. MIDI is what carries the message your electronic instruments receive in order to make noise.

How Does It Work? MIDI allows musicians to play one keyboard (or another MIDI-compatible musical device) to achieve the sounds of a second. MIDI literally allows you to play two or more keyboards (and other devices) at once. I will describe this in more detail in a moment, but simply put, you can press the keys on one keyboard and have one or more ring out without ever touching them.

Let's use two electronic musical devices, such as a couple of synthesizers, in an example. (As you will see, any two devices such as computers, VCRs, basic MIDI modules less actual keys to press, recording machines, lighting panels, mixing boards could be used.) Synth 1 is currently programmed for a harpsichord sound. You also want Synth 2 to play in the same key, but with a different texture.

How do you play a note on Synth 1 and have that same note ring out from Synth 2? To answer this, first let's consider the physical aspects of MIDI. In order for MIDI data to be transmitted and received, both machines (or however many you want to use) must be MIDI-ready, meaning these modules must have MIDI ports. On the back of any number of keyboard synthesizers is a MIDI jack. Some keyboard instruments have what is known as a MIDI IN and/or a MIDI OUT jack. Some also have a MIDI THRU, but more about that later.

The MIDI OUT of Synth 1 (or what we'll call the "controller" keyboard) is linked via a male DIN connector to Synth 2's MIDI IN, thus enabling the transfer of information from Synth 1 to Synth 2. Remember, the transfer of messages allows sound to be generated.



The Surface One virtual MIDI controller receives user input via a fiber optic-based, touch-sensitive "smart fabric" that was developed by the Canadian Space Agency.

The sound is then heard with your ears through an amplifier and speaker setup.

The MIDI message being carried is called a "command." In each command is the signal for a note to ring out or to stop. These MIDI commands, and all others, have a byte sequence. (Note: there are a number of different commands, whose function and execution are quite complicated. More about those in the Sidebar.) The byte sequence includes a signal for NOTE ON, which tells a second synth what note to play, in what pitch, and at what volume. NOTE OFF simply stops sounds from being generated. Automatically, as a musician presses a key on Synth 1, a NOTE ON MIDI message (and all other messages sent from Synth 1, including what note to play) is transferred to Synth 2.

Sound modules communicate through MIDI's 16 channels—numbered 1 through 16. A musician can determine on what channels to send and receive information for each keyboard. Synths will respond to all 16 MIDI channels in a mode called OMNI ON via an OMNI ON MIDI channel message. (An OMNI OFF channel message tells the receiving device what specific channel is to respond.)

Let's say that Synth 1—our "controller" keyboard—sends a command that is assigned to the machine's Channel 1. The musician then sets the second instrument, Synth 2, to respond to Channel 1. Once the modules are set to the same channel, a MIDI event can occur. In other words, you'll hear the note you want. Think of channels, if you will, as if these machines are CBs locked into the same frequency. You can't hear the other party unless he/she is on the same channel. If you play a NOTE ON on Channel 1 on Synth 1, but Synth 2 is not programmed to listen on Channel 1, you have a non-event. Nothing happens.

Now, to complicate matters, what if you have three MIDI devices? You have to complete what is called a daisy chain. To daisy chain three MIDI- compatible instruments (or pieces of gear) one or more of the modules needs an extra port (a MIDI THRU port). The MIDI THRU port essentially replicates the data that is coming in from the Synth 1's OUT port and passes it along to another device. Note: Not all units have MIDI THRU ports. Synth 1's OUT is connected to Synth 2's IN via a MIDI cable. Synth 2's THRU port (if it has one) is then connected to Synth 3's IN jack. Any sound the third device would make is being controlled via the first keyboard. When all three machines are on the same channel, all three keyboards could be playing the same note.

What if you want a particular note played by Synth 1 to be repeated on Synth 3, but not Synth 2? Simple. You would assign Synth 2 to a different channel. In this way, Synth 3—which is pro-

Important MIDI Messages

As we have seen, MIDI messages are what is carried via MIDI cables from one device to another. Let's take a closer look at some of MIDI's channel and system messages.

NOTE ON: This channel message is transmitted from a controller keyboard to a receiving keyboard/module. This data tells the module how fast/hard, and on what channel a specific noted was played. Each key on the keyboard is assigned a number and that number is part of the "Note On."

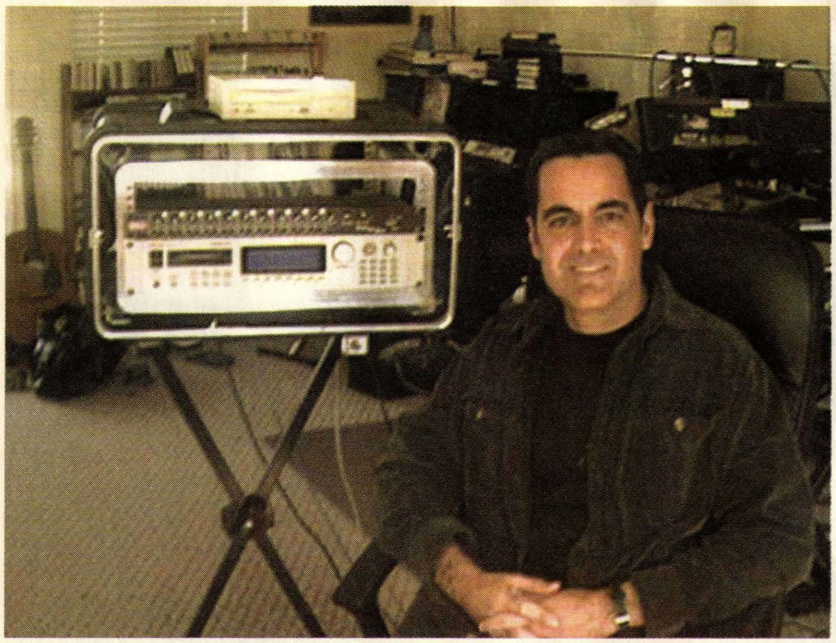
NOTE OFF: Simply put, it registers when a note is stopped. Also measures the speed at which a key was released.

After-Touch: This message registers the pressure at which keys are struck.

Program Change: When you access different patches from your keyboard sound memory banks, that change in sound is registered as a program change message. In this way, the receiving keyboard recognizes the data being transmitted concerning this sound patch. Remember: the patch number is sent across, not the actual sound.

Continuous Controllers: To recall the dynamic sounds of vintage synthesizers, the MIDI system uses controllers (sliders, wheels, foot pedal for volume) to provide a full range of performance options to musicians. Each control device/ method corresponds with MIDI's 128 control numbers. Those numbers are what is transmitted from machine to machine.

System Exclusive Message: A coded message corresponding to a specific manufacturer. Sys-ex messages are commonly used to communicate data concerning the instrument's "patch" banks. Musicians can manipulate these codes to customize their sounds.



Neal Morse has been an avid user of MIDI technology for composing and performance. Here he is seen taking a breather in the studio.

grammed to receive a message on channel 3, let's say—is the only device that recognizes the data being sent by Synth 1 on channel 3. Meanwhile, Synth 2 remains silent. It will also work in reverse: if you want Synth 2 to ring out, but not Synth 3, just set Synth 1 to transmit on channel 2 and program Synth 2 to receive on channel 2.

Sequencers, Samplers, And One Man Bands. This writer's first experience with MIDI was with Simmons electronics drums—those hexagonal playing pads (that looked like Stop signs)—that were to make traditional acoustic drum kits obsolete. For a while it looked as though they would. These hard plastic drum surfaces started popping up everywhere, on stage and on record, and their characteristic clanks and fabricated noises could be heard on a number of popular 80s tunes.

Through an electronic device referred to as a *brain*, Simmons drums stored prefabricated sounds in digital format. Each drum pad could be assigned a separate sound/noise/timber. Every time Pad 1 was hit, it would garner a timbale, or bell, or whistle noise. How was this possible? When the pad was struck with a hand or a stick this motion was picked up by a *trigger*, which sent data to be processed by the brain. The brain then sent out the info in the form of sound via a PA system, amplifier, or out through your headphone jack into your headphones.

Add-on features were available, and the Simmons drum brain could be connected to a number of MIDI compatible devices, such as a sampler. Since most of the Simmons' drum brains had a MIDI IN and/or MIDI THRU jack, the brain became part of a chain and any number of sounds could be produced. The brain's MIDI OUT could be connected to the sampler's MIDI IN and any other devices were added using the MIDI THRU portal.

Bill Bruford, the former drummer of Yes, King Crimson, and Genesis, threw himself headlong into new technology and soon gained a reputation as a pioneering electronic drummer. Bruford went on to lead his own jazz band Earthworks, in which he used preprogrammed keyboard sounds and samples to play whole notes right from his drum kit. He was literally playing music on his drums. Bruford eventually upgraded, and went off the deep end of cross-fading and touch sensitivity.

As he once told Modern

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Roland's ED PC-300 USB (a 49-note velocity-sensitive controller keyboard that uses Cubasis software for Macintosh or Windows.)
MSRP: $159.99

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AKAI MPD16 USB Midi Pad Control Unit: Equipped with 16 pressure sensitive pads, the Akai MPD 16 is designed to be a programmable drum machine. Connects via USB and/or MIDI (port) to computers and sound engines such as the Akai Z4 and Z8 samplers.
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MIDIMAN's Oxygen 8. (see main article.) No MIDI interface is needed for this hands-on control device which features eight MIDI-assignable knobs. Its 25 keys send all kinds of MIDI messages that speak directly to your computer. Powered by USB port, 6 "AA" batteries, or included power supply.
MSRP: $179.95

Encore Electronics' Knobby Programmable MIDI Control Service
This certainly puts the power back into musicians' hands.
"With so many mouse-friendly devices on the market these days, I think musicians want to actually put their hands on something and really feel themselves creating the sound," says Encore owner, Tony Karavidas. Karavidas developed the "Knobby" which interfaces with current, obsolete, and future MIDI equipment. Programmable Sys-ex messages; compatible with your PC.
MSRP: $249

Drummer magazine, "(Hitting) the pad, and how hard you hit it, are both read and the subsequent sound is controlled accordingly. You can also have cross-fade samples. This means that you can assign several samples to the same pad. For example, your child's voice can turn into a bell, which can turn into a gong—all cross-faded so you don't notice the joins."

As the technology progressed, so did the sonic options. Drums, of course, were not the only instrument making leaps and bounds in the 80s. Today, all MIDI modules have 128 standard-note voicings that are assigned numbers. This is known as General MIDI. (Note: In recent years, General MIDI Level 2 was developed to be an extension of General MIDI Level 1. GM Level 2 ups the ante by increasing the number of sounds available to musicians. All GM2 devices are compatible with General MIDI Level 1.)

Think of these voicings as stored digital-sound patches including bits for instruments such as horns, bass, drums, woodwinds, etc. From MIDI machine to MIDI machine, each sound family is grouped together. So, strings are all grouped together in your MIDI machine's memory banks. Percussion instrument samples form another cluster. Keyboard samples form yet another. Get it? It's a kind of universal code to make the recording and exchange of digital information easy between musical equipment made by different manufacturers. To play these sounds, you'd go into your instrument's memory banks and program a sound source.

What has helped to orchestrate many a musicians' compositions was the advancement of polyphonic keyboards. A polyphonic keyboard plays more than one note at a time (some keyboards offer up to 64 voices). In our example above, we were sending basic, or monophonic, information across only one channel. In theory we could send information about a number of different notes across a number of different channels simultaneously.

Your sound palette can be augmented through the use of a sampler. A sampler is essentially a digital warehouse, a library of stored textures. "I'll use my Alesis QuadraSynth with a MIDI sampler which has some vintage sounds like a mellotron," says Neal Morse, creative force behind the neo-prog rock band Spock's Beard. "I use a mellotron sound sparingly, so having that programmed keeps me from lugging an old vintage piece of equipment."

"I have one keyboard where one key could be assigned a horn, or percussion, or whatever—a cricket sound if I want—and everything I need is in that one keyboard," says Sam Rosenthal, of the New York band Black Tape For A Blue Girl.

Using the many patches and stored sounds from a sampler, it didn't take long for musicians to realize that they could be one-person bands. "You could be a one-man band before the advent of MIDI, thanks to multitrack recording, but you had to be able to play all the instruments in real time," explains jazz violin great Jean-Luc Ponty, who has been using MIDI since the early 80s. "Now we can play different instruments thanks to the combination of MIDI and sound samples. On my 2001 record, *Life Enigma*, I added percussion and drums to the song *Lonely Among All*, right from my keyboard. I did the whole thing myself."

Jazz violinist Jean-Luc Ponty has been using MIDI since the 80s. "...I added percussion and drums to the song Lonely Among All, *right from my keyboard."*

Thanks to the pioneering efforts of Richard McClish, who co-founded Zeta Music in the early 80s, Ponty uses a Zeta 5-string violin with a MIDI pickup under each string. When Ponty plays his violin, the MIDI message is sent to a Zeta VC-225 controller, which interprets the commands and sends them out to a synthesizer of his choice where he has programmed a range of different colors. The digital information is then amplified via a sound system.

"The violin can be played alone, as a blend with a synthesizer, or muted so one can only hear the synthesizer," says Ponty. "I run my violin through a Zeta VC-225 MIDI controller, then I use a Proteus 1, Kurzweil, or my Synclavier keyboard, depending on what sound I want."

Both Morse and Ponty have extensive experience with sequencers. Sequencers are devices that can "record" a single performance and then play it back

much like you would with an analog recording machine. Why are sequencers important? Think of it this way: you can perform seemingly endless performances and weave them together. All of those "tracks" can be played from the sequencer while you are off playing a completely different melody line. Once again, you can be a one-person band.

Note: Some computer software programs are actually sequencers. Using internally stored sound information, known as a sound card, these sequencers generate a preordained passage. If you've ever pushed PLAY on a Windows Multimedia Player, you've experienced playback MIDI files in action.

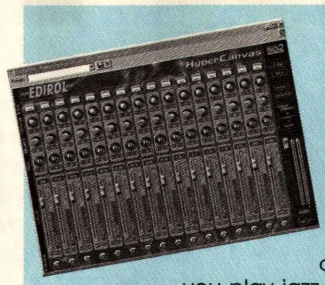
You may want to add another device—a sound module with an array of keyboard sounds. To do so, you'd hook up Synth 1's MIDI IN to the sequencer's MIDI OUT, then the sequencer's MIDI OUT to the sound module MIDI IN. To complete the chain you'd send a MIDI cable from the module's MIDI THRU to Synth 1's MIDI IN. This is called a "patch through" and gives you access to the sound sources and the ability to record with the sequencer.

One final note: once your performance is recorded, you can change the sound quality of each performance by changing the set sound on your multitimbral module. Keyboards that are capable of playing more than one note on more than one MIDI channel simultaneously are called mutlitimbral. Since the sequencer records the performance (meaning the action of your hands on certain keys—not the actual sound), you can access different tones and change the feel by switching channels. For more about sequencers check out "What's MIDI?"—see Sidebar.

MIDI In Another Dimension. Throughout the 80s, the uses of MIDI were varied. However, by the time the mid 90s rolled along, many people had labeled MIDI as an "outdated" technology; this was a mistake. With the rise of home-based and laptop computer recording, MIDI is making a comeback of sorts. Today, MIDI is being used in conjunction with any number of musical and non-musical devices.

"Lighting companies got hip to the fact that music and visual effects can go together," explains Timothy Chen, project manager at MIDIMan, a leading manufacturer of MIDI-ready products. "You can play a C sharp on your piano and instead of a C sharp being heard, a red light goes on."

"How?" continues Chen. "Let's say you have a lighting system that accepts MIDI control. You can connect a MIDI device like the Surface One into the lighting panel and you are set to go. On the Surface One are four main slider "pads" that are controlled by touch. If you slide your fingers down on this touch-sensitive pad, you can shut off the lights. If you slide them up, you turn them on at full power. The other cool thing about it is, if you push down on these pads, you can make the lights flicker or spin or flash. Really, you can make those lights do anything you want. It is all in the way you map it." Note: To *map* a device is to take the information



SOFTWARE

1.) ***Edirol Hyper Canvas HQ, GMS Software Synth***—The Hyper Canvas, a virtual synth and sound source, has 256 sounds, 9 virtual drum sets and over 500 tone variations (128 variable drum sounds) that helps you play jazz and rock with studio-quality instrument sounds. It runs on Windows 98 (128MB RAM, 100 MB free disk space with Windows audio interface and CD-ROM drive; or Mac OS 8.6.1, 256 MB RAM, 100 MB free disk space with Mac audio interface and CD-ROM drive.) MSRP: $199.00

Also Available:
Edirol Super Quartet. The Edirol website (*www.edirol.com*) notes: "The ultimate Plug-In Software Synthesizer set of four contemporary music instruments - Piano, Guitar, Bass, and Drums."
And, the Edirol SoundCanvas VSC-MP1 Virtual Sound Canvas Multi Pack: it puts all the sounds of a modern day symphony orchestra at your fingertips.

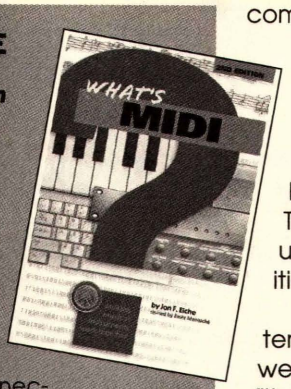
2.) Voyetra Digital Orchestrator Plus—This package lets you create multi-track MIDI recordings of your own music or modify prerecorded MIDI songs as well as edit and record audio files. It allows the user to compose songs step-by-step by entering notes with a mouse or MIDI keyboard, then edit every detail on the PC screen. You can cut and paste whole sections of music (as well as MIDI notes of any length) and import .WAV files (drum samples and effects). You can also record multiple MIDI tracks, rearrange the song structure with copy, move and delete functions. Also includes virtual audio mixer which allows you to control tempo, volume, panning and other features. The *Orchestrator Plus* will also convert MIDI data into standard music notation so you can print sheet music on any Windows-compatible printer.
MSRP: $39.95 (as a download at *www.voyetra.com*)

3.) *Cakewalk*—As the name implies, *Cakewalk* software systems have always been user-friendly, low-maintenance programs for recording music in the comfort of your own home. According to *Cakewalk*'s website (*www.cakewalk.com*), its Home Studio 2002 is the top-selling home software recording package in the world. With these features, it's no wonder why. Users can record and play back unlimited tracks of audio and MIDI, import WAV, and MP3 files (and more), use synth plug-ins to add hundreds of high quality instrument sounds, edit and print notation, and more. $49 for registered Cakewalk customers; regularly $129.

4.) Steinberg's *CUBASIS VST*—The VST turns your Mac or PC into an 8-track studio with effects, drum loops, and riffs for sound designing. You can record both MIDI and digital audio, compose scores and soundtracks for video. Mac requirements: 6100.66MHz minimum, 16MB RAM minimum — 24 recommended, CD-ROM drive, 2nd level cache, MacOS System 7.5 or higher. Windows: 200MHz Pentium processor, 32MB RAM, Windows 95/98, MME or ASIO compliant sound card, and CD-ROM drive. MSRP: $99.99

Also Available: **Steinberg's *CUBASIS VST 2.0*** for your Mac with 48 audio channels (WAV and MP3), 64 MIDI Channels and editing, mixing capabilities. And *CUBASIS VST 3.0* for your PC to compose songs, edit sound, print scores, produce videos and burn CDs with surround sound. Cubasis VST is the perfect tool for making your music: on your computer or over the Internet.

REFERENCE



Sound Advice On MIDI Production
(Artist Pro/ Hal Leonard Corporation)
By Bill Gibson
Complete with an accompanying audio CD, this 78-page softcover takes you through basic MIDI connections, daisy-chaining, MIDI recording, layering and interfacing with mixers. A very informative little package.
$14.95

How MIDI Works (Hal Leonard Corp.)
By Peter Lawrence Alexander
Edited and illustrated by Caroline J. Whitear
Crammed with easy-to-read passages, detailed diagrams, and even chapter-ending pop quizzes, this tome gives plenty of info on the applications of MIDI in a digital recording environment. Great for beginner and advanced user.
$29.95

Also, check out:

What's MIDI? Revised 2nd Edition
(Hal Leonard Corp)
By Jon F. Eiche
Revised by Emile Menasche
A must have beginner tutorial that tackles everything from MIDI connections to sequencers.
$6.95
(To order: 1-800-637-2852 *www.musicdispatch.com*).

Make Music Now! (Backbeat Books)
By Mitch Gallagher
Magazine editor and professional musician, Gallagher explores many home-based recording applications which includes the use of MIDI.
$17.95

VHS: *Understanding MIDI*
(Artist Pro/Hal Leonard Corp.)
with David Wills
A good starter video that states the basics clearly and succinctly. Not a lot of rewind, pause and playbacks to understand these basic MIDI concepts.
$19.95

You can find any number of instruments and reference guides on the web. Here are a few links:

www.ebay.com
www.musiciansfriend.com
www.samash.com
www.zzounds.com

coming into a MIDI unit and reconfigure it to achieve a completely different sound.

You can dim the lights yourself when you want to have a slow number, or shine them brightly for a heavy number. The Surface One, and other units like it, offers endless possibilities.

"You can control the parameters of the sounds like the pitch as well as the variables like LFOs and filters," says Chen. "You can map this to percussion and play hand drums with it. I know a tabla player who wants to get his hands on this because he wants to map it to tabla samples on his computer and play a multitude of sources. He wants to be able to play two or three different drums at his lap. How it works is the musician will be using the pads as triggers since the pads are touch sensitive. At the top of the pads you could have samples of a high-pitched tabla and at the bottom maybe sounds for big, deep sounding tabla. You could play all this with your fingers."

Because the touch-pad fabric of the Surface One can read movements in all directions—up/down, left/right, as well as how hard you press—it can send multiple messages simultaneously to control a number of actions.

"You can control your guitar rig, what's happening with your software for your software synth samplers, video, all at the same time," says Al Schnier of the rock group moe, who has used a number of MIDIMan products.

Schnier used the sister to Surface One, the Oxygen 8, on stage when he toured behind his solo record, *al.one*. "The Oxygen 8 is a small keyboard with 25 velocity-sensitive keys," says Schnier. "I didn't need a large keyboard because I would be playing some simple lines. The eight knobs could be assigned to anything I needed them to be in the software I was running. What was great about it was I could have a MIDI controller playing a part on the computer and I would have one of the knobs on the Oxygen 8 be assigned to a particular voice, or patch. I could be playing a piano part and as I scroll the knob back and forth it could go from piano to electric piano, to Wurlitzer back to piano."

Computers And MIDI. Thanks to the advent of computer-based recording, MIDI has found another life inside the virtual world of PCs. Schnier's *al.one* was primarily written, arranged, recorded, and composed on a G3 Lombard PowerBook Mac. From a computer with a 400-MHz processor, 256Mb of RAM and an 8-G hard drive, Schnier melded MIDI and high-tech recording.

"My controller keyboard hooks up to my computer via a USB cable," says Schnier. "I was running a MIDI program on my computer called *Reason* made by Propellerhead. *Reason* is a virtual rack of audio gear that includes software synths, samplers, drum machines, mixers, EQs, and compressors—anything you need to make a record. The only thing you are limited by is the handling capacity of your computer. I could record 128 tracks if I wanted to."

Because of ease and portability, Schnier began creating music for this record from the back of moe.'s tour bus. "With the MIDI controller and laptop you have an unlimited number of voices you can produce," says Schnier. "You can pull a cello sample up and tweak the parameters until it doesn't sound like a cello anymore. That is something new you have created. You can also bring in other sounds from other sources or use your own sampled noises and plug them. You can even loop that sound with a loop player if you want. For instance, I can record my kid's crying if I want to and then play it back on my keyboard and script it into a song. There are so many options with MIDI—I'm so excited about the prospect of things to come." P

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Virtual Graffiti: Creating Your Own Music on a PC

EDWARD B. DRISCOLL, JR.

Paul McCartney's first solo album, completed just before he left the Beatles in 1970, was recorded entirely in his Scottish farmhouse, and yielded *Maybe I'm Amazed*, a gorgeous hit song. In between big-budget studio albums, Bruce Springsteen recorded *Nebraska*, a collection of stark, personal tunes, entirely on his Fostex four-track cassette recorder. Phil Collins' first solo album contained songs such as *In the Air Tonight*, which began life in his home studio, but were completed in a professional studio.

With today's PC-based home recording technology, you can join them (OK, we can't guarantee the same level of chart-topping success, but you never know!). It's easier than ever to create your own music at home—even if you don't play an instrument—using a PC, some software, and if you really want to get into it, some additional hardware. We'll tell you how.

Who Is The Typical Home Recording Enthusiast? Bill Park, a Sysop of Compuserve's MIDI and Home Recording Forum, thinks that most home- recording enthusiasts are average fellows over 30 with some music experience. "Once you get past that age, there is enough income for some discretionary spending, and there is the need for an outlet." And by that age, with the combination of a steady job, a family, and responsibilities, it becomes harder to be in a band. "But the creative urges are still there. The school teachers, accountants, and other typical adults are finding that with a modest investment they can still make music without all of the hassles involved in keeping a band together, and end up with a CD that they can inflict on their friends."

PC-based home recording has revolutionzed the independent music scene.

One person who seems to fit that bill perfectly is Glenn Reynolds, a forty-something University of Tennessee law professor, whose constantly-updated Weblog of news and opinions, *www.instapundit.com,* is a hugely popular stop on the Net.

In between teaching law, writing books, and running his own Web site, Reynolds also records techno-dance music under the name of "Mobius Dick" (*www.mobiusdick.com*). Reynolds describes the music as "tech-core, tech-energy, with a bit of 2-step and tech-house. I write songs occasionally for other acts on the small-record label I run with my brother and a friend, Wonderdog Records. I've written some tunes for the Nebraska Guitar Militia and the Defenders of the Faith, for example."

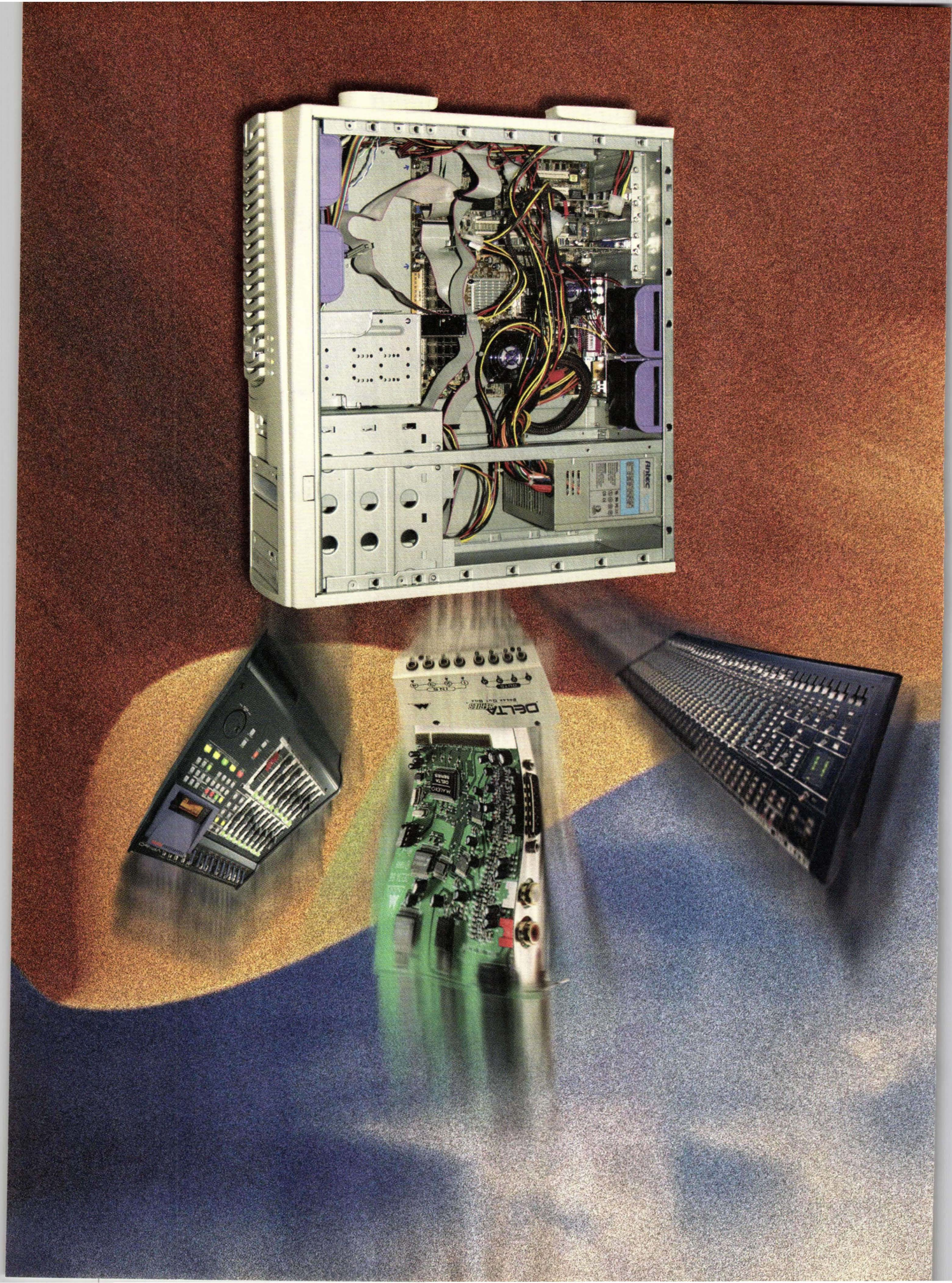
How does Reynolds find time to record music as well as juggle his day jobs? "The key," he says, "is to use your time well. There are a lot of wasted hours in most people's days."

That's another advantage of home recording. Unlike a professional recording studio and hourly charges, once the basic software and equipment is paid for, home studios are free. Want to spend six hours tuning your guitar? Go for it! Five hours getting a riff absolutely perfect? Knock yourself out. Three days (off and on) on lead vocals? Fire away.

Which is also why many professional musical acts often record at home and then complete those tracks in a professional recording studio.

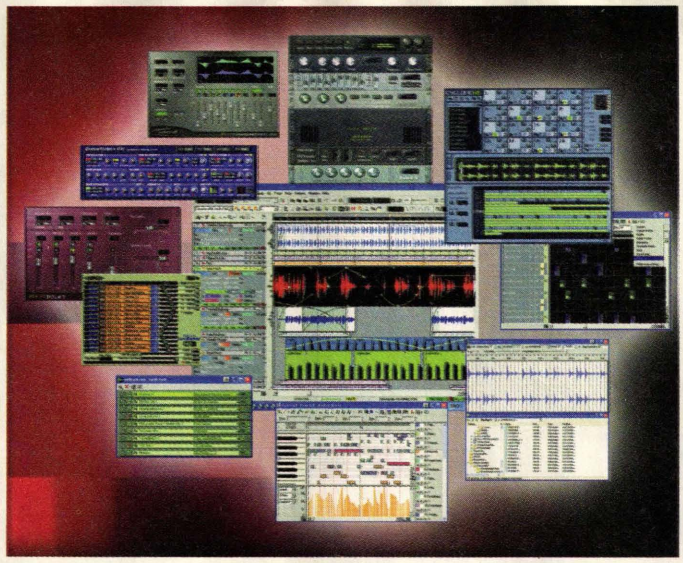
Sound-on-Sound. While superstar musicians have been able to afford home- recording equipment for decades (or in the case of pioneering electrical guitarist Les Paul, they designed and built the gear themselves), it wasn't until the 1980s that home-recording was available for the masses. That was the decade when 'four-track' cassette decks, using technology adapted from the failed quadraphonic sound systems of the 70s, began to be sold by companies such as Fostex and Tascam, to offer any musician with a spare $1000 or so (often much less) the ability to record demos. These machines provide the basic building block of multi-track recording: the ability to record sounds on individual tracks, and to manipulate one track without disturbing the other. Thus, a single musician can record a drum machine, then play bass, then play guitar, then sing a vocal, and "write" a song by using his four-track cassette recorder. The results, however, tended to be somewhat limited production values, a somewhat limited song, and a very laborious process.

However, tape-based recording has largely been rendered an anachronism by PC-based systems. Beginning in the 90s, the combination of rapidly falling


Antec
DELTA 44
Built Out Out

prices, and equally rapid increases in computing power, has allowed the PC to become a powerful recording tool, capable of performing tasks that in the past required tens of thousands of dollars worth of professional studio gear to achieve.

Today, simple home-recording software allows anyone to compose and record music entirely from within his or her own PC. Many entry-level programs are automated sufficiently to allow even non-musicians to assemble and record personal compositions.



Cakewalk's Sonar2 XL *is a digital audio/MIDI sequencer for the PC platform that allows users to produce professional recordings from the comfort of home.*

So why record on a PC instead of a dedicated recorder? Chris Rice of Cakewalk (*www.cakewalk.com*), a leading music software publisher, says that a big reason is "a dedicated recording deck does not give you any visual representation of the music. And for you to go and try to edit what you've recorded is quite laborious and quite painful. You often have to go back and just punch-in, and record over."

Rice describes the difference as significant as the equivalent of typing on a typewriter, and using a word processor. Seeing the music on the screen makes it possible to move an instrumental part that's slightly ahead or behind the beat, cut out a muffed note or phrase, change the pitch of a phrase, or insert or delete whole bars of a song. Very much in the same way that a word processor allows words to be manipulated, a home-recording program does the same for music.

What's Out There? The first level of home-recording programs, such as *Acid*, by Sonic Foundry (*www.sonicfoundry.com*), utilize pre-recorded loops, which can be assembled, mutated and modified into a seemingly infinite variety of permutations by a PC user with absolutely no previous music knowledge. For many people, these loop-based programs are all that they need to begin to make their own music.

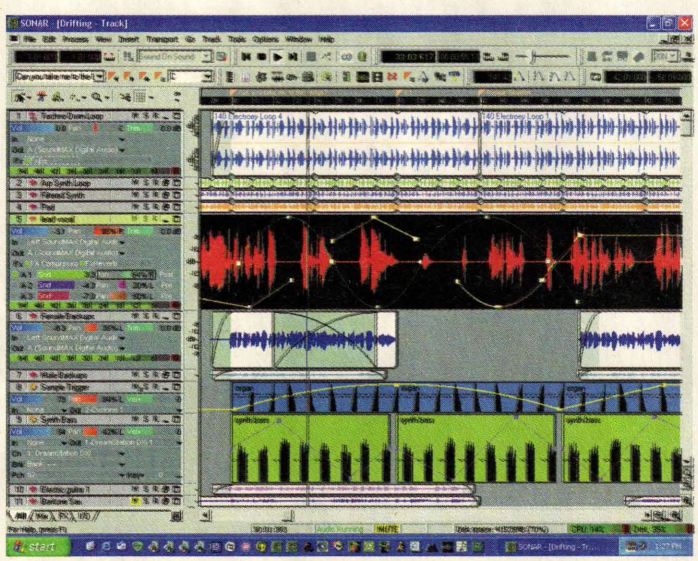
To go beyond loops, it quickly becomes necessary to record your own sounds. Keyboard players have had a leg up on other musicians in this area, because in the early 80s, synthesizer manufacturers invented a common language to allow equipment made by a variety of manufacturers to talk to each other, and be controlled by computers. This language was named MIDI, short for "*m*usical *i*nstrument *d*igital *i*nterface." The online music forum, Harmony Central, has an extensive collection of faqs, links, and other material in their Midi section (*www.harmonycentral.com/MIDI/*).

A MIDI-equipped keyboard allows you to input directly from your keyboard into the computer. The digital information can then be manipulated on the computer, rather than on the keyboard.

It has only been in more recent years that software and hardware interfaces have been developed to allow such easy input from guitars (and other instruments). We'll discuss those a little later.

Bringing Music into the PC. For more complex home-recording applications, there are several options, including sophisticated multitrack recording programs that will record dozens of MIDI and audio tracks to a PC. With some programs, there is no fixed number of tracks—the only limitation is how much the PC can handle without crashing or slowing down.

Sonic Foundry's top home recording program is called *Vegas Audio*. Cakewalk's is called *Sonar XL*. These are *very* sophisticated programs that combine loops, digital multitrack recording, MIDI,



This screen capture shows the track view of Cakewalk's Sonar2 XL. *Each color bar represents a different audio input that can be altered and manipulated via the GUI.*

sophisticated audio effects, and lots of room for expansion. Think of them as being much like a professional recording studio in a box.

Chris Rice says, "Let's go back to the standalone multitrack recorder. OK, you've got a multitrack recorder. You're a guitarist. What about the other parts? What are you going to do? You've got a drummer to come over? You've got a singer to come over? You've got some horns?"

With programs like *Sonar* and *Vegas Audio*, between prerecorded loops and the ability to "write" music right into the program via MIDI programming, "all that's built in," Rice says. "You can put together the other parts yourself if you want to, or you can bring your band in, and you can all record right into the PC. It just offers you so much flexibility."

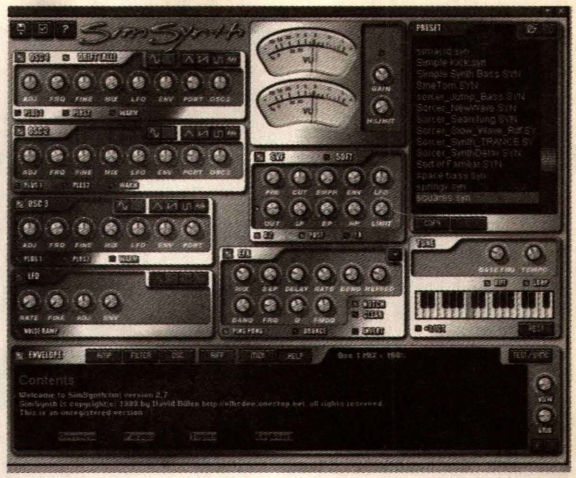
Spanking the Plank, 21st Century Style. While keyboard players definitely have an easier time of it when it comes to computer-based recording, several recent products make it easy for guitarists to record using PC-based systems, without having to place microphones in front of amps turned up to #11 (nothing like having the police show up on your doorstep at midnight while you're trying to record).

One such product is Line6's GuitarPort. Line6 (*www.line6.com*) has manufactured a line of amps and effects boxes for guitarists which recreate the vintage sounds of the 50s and 60s vacuum-tube powered amps beloved by electric guitarists for their warm tone, and when overdriven, their "musical" distortion. Now the company has created an interface and accompanying software that essentially allows any electric guitarist to plug the quarter-inch output jack of his instrument's cable into the USB port of his computer.

Professional electric guitarists and serious amateurs spend years crafting the tone of the instrument, and most would probably say that a vintage amplifier sounds better or more authentic than Line6's computer-driven recreations. However, to my ears, the sounds of the GuitarPort are pretty darn good, and amazingly diverse. The 78 or so other presets run the gamut from 1950s style small amps perfect for B.B. King and Muddy Waters style blues leads, to shredding heavy-metal buzz-saw sounds and all points in between. And of course, all of the unit's simulated amps, speaker cabinets, and effects can be tinkered with, assembled and dissembled for even more tones.

A similar product, while it lacks the hipness of a USB input, and thus requires being plugged into either the computer's soundcard or a mixing board (more on those in a moment) is Roger Linn's AdrenaLinn box (*www.rogerlinndesign.com*), which combines a hundred preset sounds synced to a built-in drum machine whose tempo can be controlled via MIDI. (Linn is famous for the LinnDrum–the drum machine that was on seemingly every hit record of the 80s.)

It has an astonishing amount of sounds, ranging from screaming Marshall Amplifier-style tones to synthesizer-like sequencers and envelope followers (ala Pete Townshend's guitar solos in several songs by the Who from the early 70s, such as *Going Mobile* and *Relay*). While both GuitarPort and the AdrenaLinn have some great guitar amplifier sounds, the AdrenaLinn can also make some very *un*-guitarlike sounds. It's almost a guitar synthesizer in a box.



Sim Synth, *available from* www.fruityloops.com, *is a virtual synthesizer that allows the user to create loops for audio projects.*

Start Me Up. For many, the biggest challenge of home recording is getting started. The first time one looks at a program such as Cakewalk's or Sonic Foundry's various choices, the amount of virtual buttons, controls, and options may seem overwhelming.

The easiest way to learn how to manipulate them may be to simply lay down 24 or 36 bars or so of drums (whether from a loop, an existing drum machine, or programming the drum machines sounds built into most sound cards), then either put some loops of other instruments on top of them or play a rhythm track of whatever is your primary instrument. Then record a

SOURCE INFORMATION

Cakewalk
www.cakewalk.com

Harmony Central
www.harmony-central.com/MIDI/

Line6's GuitarPort
www.line6.com

Midiman
www.midiman.com/products/midiman/oxygen8.php

Mobius Dick
www.mobiusdick.com

Roger Linn's AdrenaLinn Box
www.rogerlinndesign.com

Sonic Foundry
www.sonicfoundry.com

Soundblaster's Live! Card
www.soundblaster.com

Tascam's US-428 Mixer
www.tascam.com/products/us428/index.php

What Kind Of Hardware Do I Need?

Rob Uhira of Sonic Foundry says that to make tracks using loop-based programs such as Acid, "then all you really need is a decent computer, say over 200 MHz, a sound card, a decent monitor to see everything on the screen, and that's it—you're able to create music on your PC. Beyond that, you may want a CD burner, so that you can burn the track to CD once you're done."

More sophisticated recording programs such as *Vegas Audio* and *Sonar* require some fairly potent computer hardware to work. "This is a personal bias," Uhira says, "because it really depends on what you're doing, but I wouldn't begin a home studio without a PC with a minimum of a 400-MHz processor, and a 7200-RPM hard disk drive, which pretty much is on everything these days." Also, some programs, such as *Sonar*, require much faster processors (at least a gigahertz, in *Sonar*'s case), and are happiest running under Windows 2000 or XP rather than Windows98 or WindowsMe.

For programs such as *Vegas Audio*, Uhira suggests that dual monitors (which most versions of Windows support) can be very handy, because "you can undock the windows in Vegas, and maybe you'd want to move your mixer to the left monitor, and then everything else to your right monitor."

You also need a soundcard, and there are numerous ones on the market designed for home recording. Some of the under $100 cards, such as Soundblaster's Live! card, (*www.soundblaster.com*) have become increasingly sophisticated, do a marvelous job of supporting software synthesizers and may be all that's necessary for a single musician to record multitrack demos.

However, soundcards have limitations. At some point, some sort of separate mixing board provides much more flexibility, allowing the recording of multiple tracks, the use of multiple microphones, and the ability to record multiple musicians simultaneously. All of these are made much easier by the use of a stand-alone mixing board. Here, the choice is between a conventional professional audio-mixing board, and one designed specifically for computer use.

One example of the latter product is Tascam's US-428 mixer, connecting to the PC via its USB port (*www.tascam.com/products/us428/index.php*). It adds to a computer not just two XLR microphone inputs, two balanced and two unbalanced 1/4-inch inputs, SPDIF digital inputs and outputs and four channels of audio in and two out simultaneously via USB, but perhaps more importantly, physical controls. There are physical knobs that can be adjusted. Faders raised and lowered. Play, record, rewind and fast forward buttons.

The US-428 comes bundled with a custom version of Steinberg's *Cubasis VST* audio recording/MIDI sequencing software. However, on Tascam's Web site are drivers that will allow it to work with a variety of other home recording programs, including varying degrees of support for the aforementioned Vegas and Sonar. (See *www.tascam.com/products/us428/downloads.cfm* for a regularly updated list of supported programs)

For a small, handy keyboard (the musical, as opposed to the QWERTY kind), the M-Audio (perhaps better known by their previous name, MidiMan) Oxygen8 may do the trick. It's a 25-key keyboard which measures 16.5 by 9.35 by 3 inches, and allows for two octaves of range (with an easily toggled button to raise and lower which octaves are currently being played) and the ability to plug into the Midi ins and outs of a soundcard, as well as a computer's USB cable. See *www.midiman.com/products/midiman/ oxygen8.php* for more details.

So how much will all of this set you back? Uhira says, "you pretty much can get all this, including a microphone, for less than $2500, so you can pretty much be on your way." That may sound like a lot of money, but the basic components can be purchased slowly over time, and basic recording and practice can be accomplished even before all of the gear is assembled.

solo above them, or sing *something* on top of them.

This will teach the basics of recording. Then, depending upon the features of the individual program, try duplicating the whole thing, and then cutting up the phrases in the second solo, move them around, play them backwards, put effects on them, etc.

Finally, mix the whole thing down to an MP3 or Windows Media program. Again, depending upon the features of the program, try putting a pinch of reverb on the various tracks, a little echo on the lead instrument, and some compression.

That's it! You've just completed your first multitrack-recorded tune! Bigger and better things await, with just a bit more practice and learning to manipulate the home recording program. Think of it like the Beatles did—as an instrument in its own right!

Music Meets Technology. With the right software, computer hardware, a few microphones and pieces of outboard gear, Bill Park says that today's musician has access to better technology in his basement "than the Beatles, Pink Floyd, or Lynyrd Skynyrd had access to when they cut their best work."

Park says that "in the end it is all about the music, not the technology." But technology interacting with music in a home studio can be a powerful force—or at least a wonderful hobby. P

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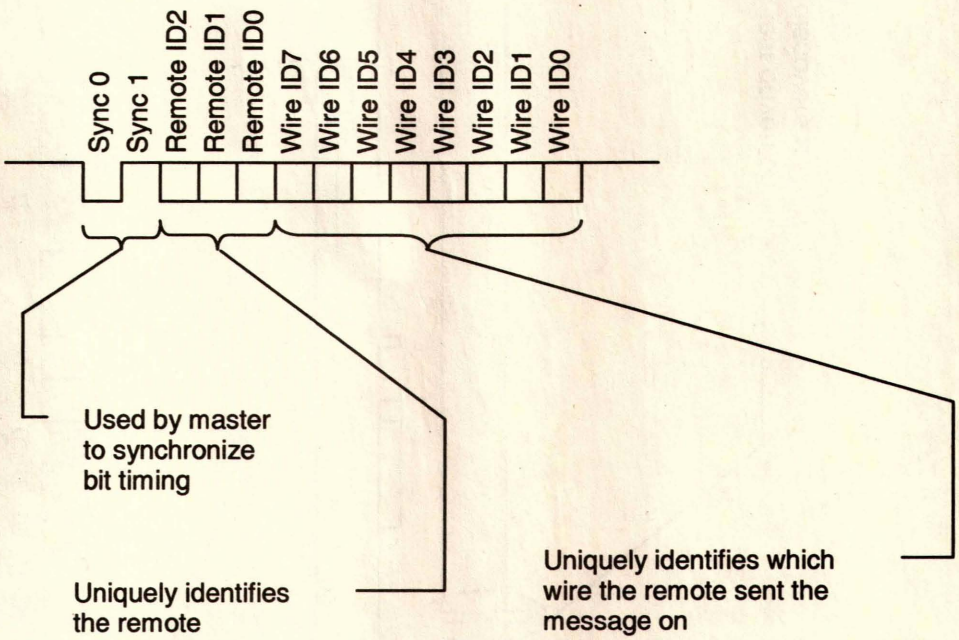

Fig. 10. Message bit format. Three bits are used to encode the remote unit's ID, and eight bits are used to indicate the wire number.

Message Protocol. When a remote unit is attached to one end of the cable and turned on, it begins looking for request pluses from a master unit. When the remote receives a request pulse on a particular wire, it responds by transmitting a coded message back on that wire. Each message is composed of a wire ID field and the remote's ID. Messages sent back on wire 1 have the first bit of their wire ID field set to 1, messages sent on wire 2 have the second bit set, and so on for each wire. See Fig. 10 for the message-bit format. Three bits are used to encode the remote unit's ID, and eight bits are used to indicate the wire number.

On the other end of the cable, the master unit sends out a request pulse on each of its wires and looks for response messages. By noting the wire number (from the master's perspective, the near end of the cable) and the wire ID in the messages (wire numbers on the far end of the cable), the master unit can determine the connectivity between the two units. For example, if on wire 1 the master receives a message with the eighth bit of the wire ID field set, then we know that wire 1 on the near end is connected to wire 8 on the far end of the cable.

Another example would be if on wire 1 the master receives a message with both the seventh and eighth bit of the wire ID field set, then we know that wire 1 on the near end is connected (or shorted) to both wire 8 and 7 on the far end. Finally, if on a given wire the master receives no messages, we know that the wire is not connected (open) to the far end.

As it scans through all eight wires, the master records which messages it receives on which wires—building a map of connectivity between the far and near ends. Once the master completes this scan, it compares this measured connectivity map to the selected reference map. If they match, the master unit indicates a pass; otherwise it indicates a failure.

Note that master and remote units are independently powered from separate 3-volt supplies. As such, they do not have a common ground reference between them. The units drive a request pulse or message out one wire at a time, only. Holding the remaining wires high by the PIC16LF872's I/O pins sets up a reference between the two units through the master unit's

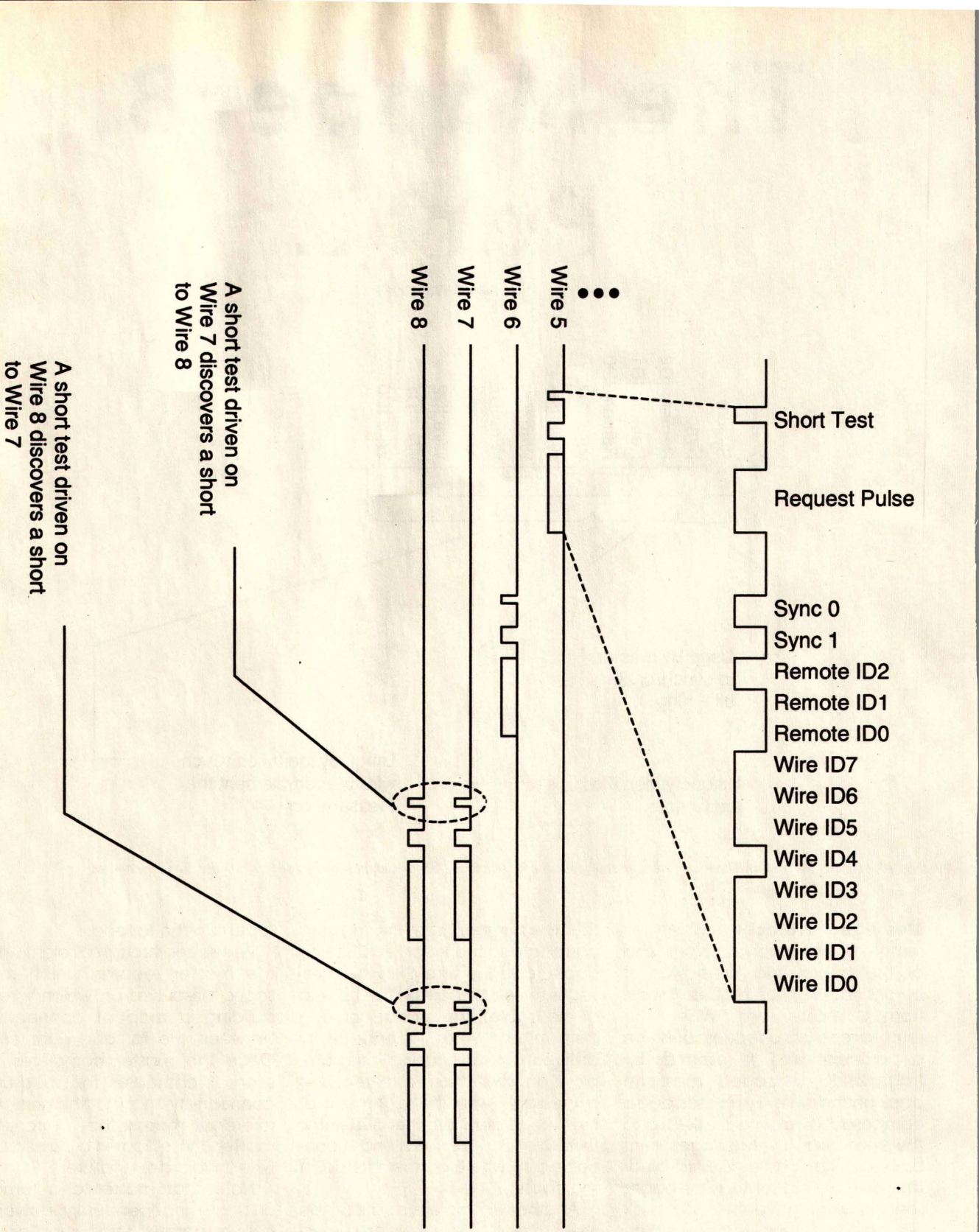

Fig. 11. Message protocol example.

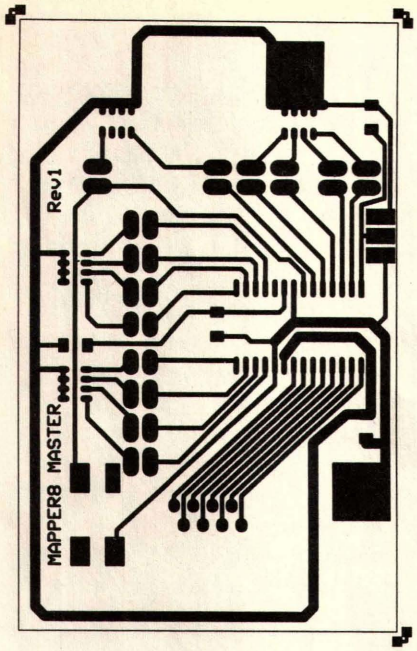

Fig. 12. Master Unit Foil Pattern. A finished size of 3.15 inches by 1.97 inches will allow the board to be used as the cover of the case specified in the Parts List.

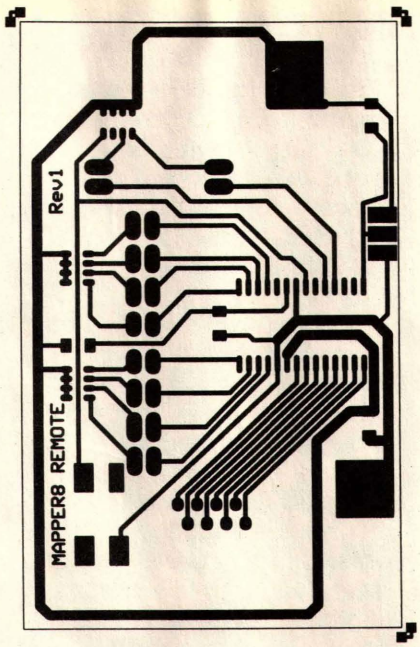

Fig. 13. Remote Unit Foil Pattern. A finished size of 3.15 inches by 1.97 inches will allow the board to be used as the cover of the case specified in the Parts List.

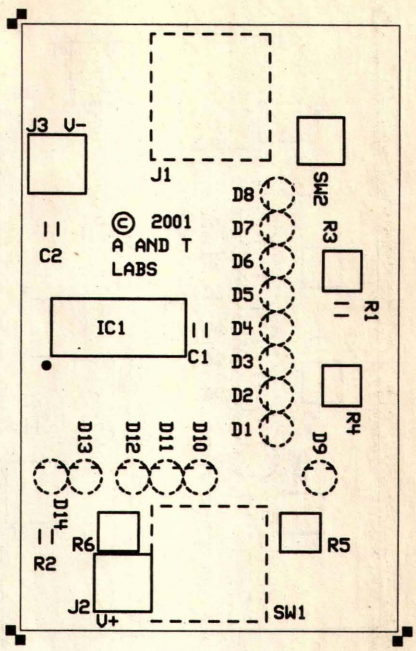

Fig. 14. Master Unit Parts Placement Diagram. Solid outlines indicate where components are surface mounted and soldered to the trace side of the board. Dashed outlines indicate where through-hole components are mounted on the opposite side.

PARTS LIST FOR THE MAPPER8

MASTER UNIT

SEMICONDUCTORS

IC1—PIC16LF872-I/SO, Microchip surface-mount microcontroller (programmed with master unit software)
D1–D8, D14—Light-emitting diode, T1, red
D9–D12— Light-emitting diode, T1, yellow
D13—Light-emitting diode, T1, green

RESISTORS

R1, R2—10,000-ohms, 1206, surface-mount
R3–R6—82-ohms, 4-unit resistor network (DigiKey 744C083820)

CAPACITORS

C1—22-pF, 1206, surface-mount
C2—0.1-µF, 1206, surface-mount

ADDITIONAL PARTS AND MATERIALS

SW1—Momentary pushbutton switch (Mouser 10PA332 or similar)
SW2—6-mm momentary tact switch
J1—8-pin modular jack (AMP 556416-1 or similar)
PC board, case (Mouser 400-5043), battery holder for two AA-cells, two AA batteries, wire, self-adhesive Velcro, hardware, solder

REMOTE UNIT

SEMICONDUCTORS

IC1—PIC16LF872-I/SO, Microchip surface-mount microcontroller (programmed with remote unit software)
D1–D8—Light-emitting diode, T1, red
D9, D10—Light-emitting diode, T1, yellow

RESISTORS

R1, R2—10,000-ohms, 1206, surface-mount
R3-R5—82-ohms, 4-unit resistor network (DigiKey 744C083820)

CAPACITORS

C1—22 pF, 1206, surface-mount
C2—0.1 µF, 1206, surface-mount

ADDITIONAL PARTS AND MATERIALS

SW1—Push on/off switch (Mouser 10PA432 or similar)
SW2—6-mm momentary tact switch
J1—8-pin modular jack (AMP 556416-1 or similar)
PC board, case (Mouser 400-5043), battery holder for two AA-cells, two AA batteries, wire, self-adhesive Velcro pads, hardware, solder

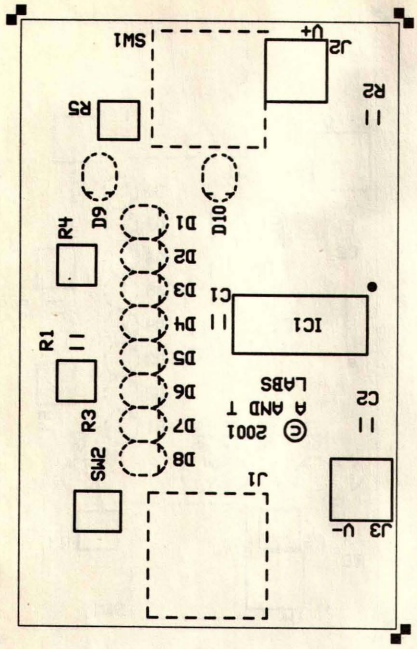

Fig. 15. Remote Unit Parts Placement Diagram. Solid outlines indicate where components are surface mounted and soldered to the trace side of the board. Dashed outlines indicate where through-hole components are mounted on the opposite side.

MAPPER 8 KIT INFO

Note: The following items are available from A and T Labs, P.O. Box 4884, Wheaton, IL 60189; Web: *www.a-and-t-labs.com*; E-mail: info@a-and-t-labs.com; Phone: 630-668-7870; Fax: 630-668-7870:

A complete kit of parts for the **master unit** consisting of all items listed in the parts list, for $39 (specify part K10MCK).That includes an etched, solder-masked, drilled PC board screened with parts-placement on one side and legend on the other side, case, preprogrammed microcontroller, all resistors, capacitors, and all miscellaneous parts. Also included is a detailed theory, assembly, test, and operation manual; Master PC board only, for $15 (specify part K10MPCB); Preprogrammed master microcontroller only, for $10 (specify part K10MCPU).

A complete kit of parts for the **remote unit** consisting of all items listed in the parts list, for $39 (specify part K10RCK). That includes an etched, solder-masked, drilled PC board screened with parts-placement on one side and legend on the other side, case, preprogrammed microcontroller, all resistors, capacitors, and all miscellaneous parts. Also included is a detailed theory, assembly, test, and operation manual; Remote PC board only, for $15 (specify part K10RPCB); Preprogrammed remote microcontroller only, for $10 (specify part K10RCPU).

Add $5 shipping for all orders. IL residents please add 6.75% to the price of each item. Check, MC and VISA are accepted.

microcontroller I/O pins. Therefore, there must be at least two separate electrical paths (wires) connected between the two units to be able to test a cable.

Another consideration is short circuits between wires. To avoid having the push-pull I/O drivers conflicting, the master first tests for shorts to a given wire before it drives out the request pulse. If a short to the wire under test is detected, then each shorted wire is also driven with a request pulse. The remaining non-shorted wires are actively driven high. The same request pulse and subsequent response message will appear on all of the wires in the shorted group. See Fig. 11 for an example of the short tests, request pulses, and response messages.

Building the Mapper8. You can make your own PC boards for the Mapper8 master and remote circuits; foil patterns for the master and remote units are provided in Figs. 12 and 13, respectively. Because some small surface-mounted components are used, a professionally fabricated board with a solder mask will make the job of soldering much easier. You can purchase PC boards and parts kits from the source given in the Parts List.

The PC boards serve both as interconnects for the components and as the cover for the plastic cases that house the boards. The PC board traces and various surface-mounted components go inside the case; while components that must be visible or accessible are mounted on the other side of the board, which ends up being the outside cover of the case. The "outside" component leads go through the holes in the PC board and solder to the traces on the "inside" of the board.

To solder surface-mount components, use a low-wattage soldering iron (15 to 25 watts) with an extra-fine tip. Be sure to keep the tip clean. Tin one PC board pad for the surface-mount component and carefully place the part so that its leads are centered on and squarely aligned with the PC board pads. Hold the part in place using the tip of tweezers or a dental pick, and then tack solder the one lead of the part. If the part is not correctly positioned, reheat the soldered lead and reposition the device. Once

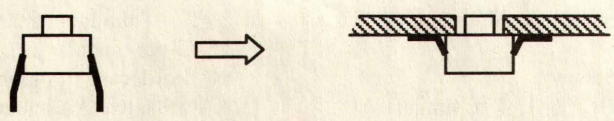

Fig. 16. Bend the four leads of SW2 as shown and surface mount it to the "inside" of the board.

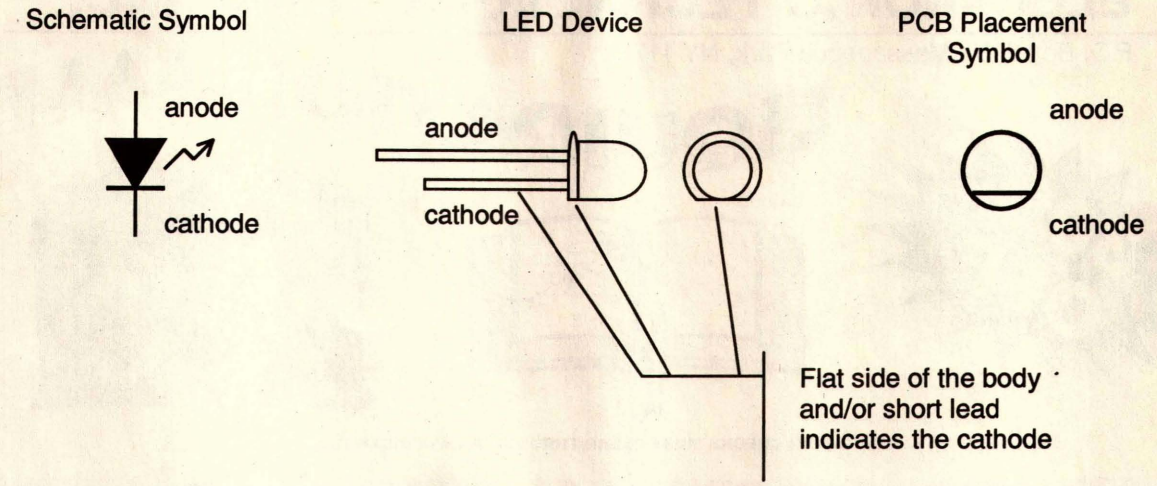

Fig. 17. LED Lead Identification. The flat side of the LED body and/or the short lead indicates the cathode.

the part is properly positioned, solder the remaining leads.

Parts-placement diagrams for the master and remote units are in Figs. 14 and 15, respectively. Solid part outlines indicate where components are surface mounted and soldered to the trace side of the board. Dashed part outlines indicate where through-hole components are mounted on the opposite side and soldered on the trace-side.

Install the surface-mount components first. Before installing IC1, make sure it has been programmed with proper Mapper8 software. You can program the two microcontrollers using hex files available at *www.gernsback.com*. Pre-programmed microcontrollers are also available from the source given in the Parts List.

To install SW2, carefully bend its leads so that it can be surface mounted to the board as shown in Fig. 16. The switch must be mounted on the board's "inside" with the switch's push-post passing through the board such that it does not bind. After the surface-mount components are soldered on to each board, install the remaining components. When installing the LEDs, make sure they are installed with the proper orientation; a flat side on the body of an LED and/or the shorter lead indicates the cathode.

The power switch (SW1 on both boards) is installed and secured to the PC board using a lock washer and nut. The switch and battery holder must be connected using short lengths of wire. You can secure the battery holder to the bottom of the case using self-adhesive Velcro. This will keep everything from rattling around and make it easy to replace the batteries in the future.

Testing the Tester. The testing procedure for both the master and remote units is more or less identical. Before installing the batteries, check for proper component placement and good solder joints. Inspect carefully for solder shorts between the small surface-mount components. Now install the batteries in the holder and apply power; the software will perform a quick test of each LED. If none of the LEDs light up, recheck the connections to the microcontroller, especially around IC1, C1, R1, and R2. If one or more LEDs fail to light, recheck the solder connections associated with the LED as well as the polarity of the LED. If several LEDs light up simultaneously, check for solder shorts around the associated resistor and pins of IC1.

Now check out the Prog switch (SW2) on each unit. Using the procedures outlined in Figs. 2, 3, 5, and 6, try changing the reference map and mode of each unit.

Finally, using a cable that is known to be good, select the reference map on the master unit that's appropriate for the test cable. Turn the remote unit on and place it in remote ID mode. Connect the cable between the master and remote units. Press and hold the master's test button and let it run through the test phase as outlined in Fig. 2. At the end of the test, the Pass LED should turn on. If the test fails, use the information displayed during the readout phase to help locate the problem (see Fig. 3). Also check for solder problems around the jack (J1) and the associated pins of IC1. On the remote unit, you should also check for solder problems around resistors R6 and R7. As a last resort, make sure that the known-good cable is actually good.

After everything checks out, install the boards in the cases and the Mapper8 is ready for action. It's easy to make adapters for other types of cables; simply attach appropriate connectors to 8-wire modular plugs and you have it. Then map a good cable as previously outlined, and it'll be a snap thereafter to test batches of the cables. P

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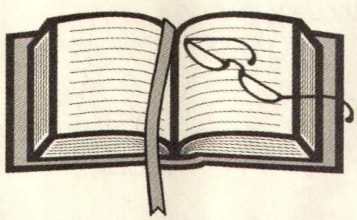

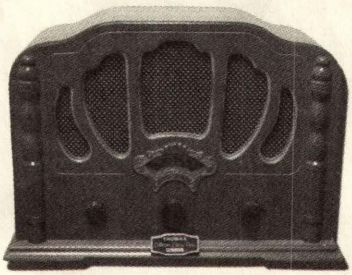

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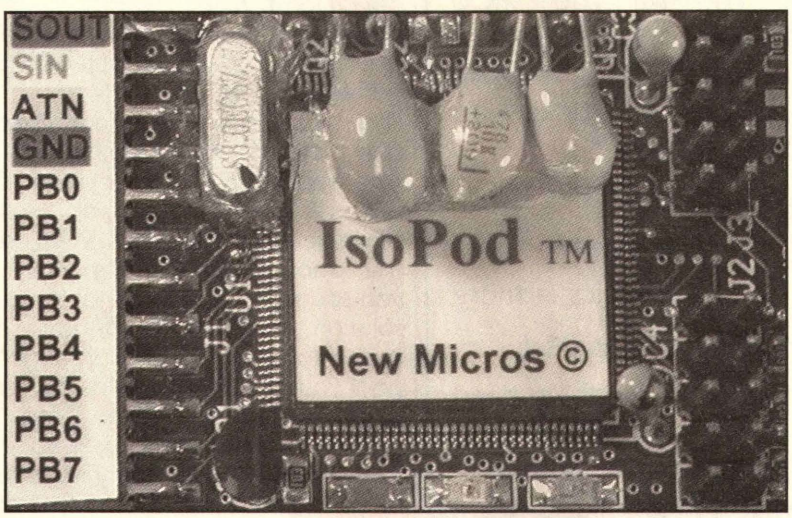
A Hands-on Electronics® REPORT

The IsoPod

The IsoPod's hardware, which integrates just about every capability you'll ever need, is coupled with a language that was created with behavioral robotics in mind.

MIKE KESSLING

I hate to waste time. In today's competitive market, I don't have the luxury of taking my time. I take pride in my reputation of designing imaginative and profitable equipment. I have been a mechanical, software, and electronics engineer in the motion-picture industry for twenty years. My computer-controlled lenses have been instrumental in making many of the motion pictures you've probably seen, such as *Saving Private Ryan* and Minority Report. In 2001, the Academy of Television Arts and Sciences recognized my accomplishments with an Emmy Award.



A Controller of Legends

If I am going to do something, I set a goal, and identify the things I need to accomplish it, and get after it. Every day I look for better ways to achieve my goals. I have spent many years looking for the one mythical controller, which might solve all my hardware and software needs. Now that I have the *IsoPod* ($99.) from New Micros, Inc. (NMI), I feel I have come much closer to finding that dream (see *www.robogeeks.com* for projects involving the IsoPod). Let me tell you how I learned about the IsoPod.

I have been a client of New Micros, Inc. for about a decade now, having used a number of their products. The "Squishy Lens" mentioned in the Emmy Award used several boards from NMI. Occasionally they develop special hardware for my projects, and sometimes they help work through various software problems. Back in 2001, the President of New Micros, Inc. Randy Dumse, approached me with an idea. He had found this ultra-powerful processor about to be released and he was very excited about it. Mr. Dumse wanted to work his particular brand of magic on it—making a controller board with an embedded high-level language designed with robotics and motion control in mind. When I looked at the specification sheet, I went out of my skin. Here was a chip that screamed motion control, and it had the processing power of a DSP. Now you can see why he was excited.

Since that time, I have had plenty of opportunity to give my input on NMI's new design. In fact, I have spent many hundreds of hours advising and tailoring this developing product's capabilities to the needs of robotics and motion control. This was like a dream for me. I'd tell Randy Dumse my wish list, and he would ruminate over it, and then implement the practical ideas. The result is New Micros' new product, the IsoPod. The IsoPod's extensive features list is going to carry me a long way towards being creative with my product's abilities, rather than wasting time integrating many bits and pieces. To understand why I'm so excited to have the IsoPod as a tool, we should discuss how a typical development project might run its course.

Anecdote

Let me present a scenario, a fictitious development cycle, and see if it rings true to what you've experienced: You have a problem to solve, so you turn to your bag of tricks—a collection of embedded processors you are familiar with, as well as the language tools to match them. Maybe you're after power, maybe it's speed, or I/O that you are after. Invariably, you find yourself in a situation where you're wishing for just one more this or that, one more "insert capability here." This could be another channel of PWM, quadrature input, A/D converter, parallel port, another I/O pin, etc. So, you add I/O expanders. Perhaps you add a coprocessor to handle floating point or drive radio-control servos on a serial channel. Maybe you opt for a serial LCD display on another

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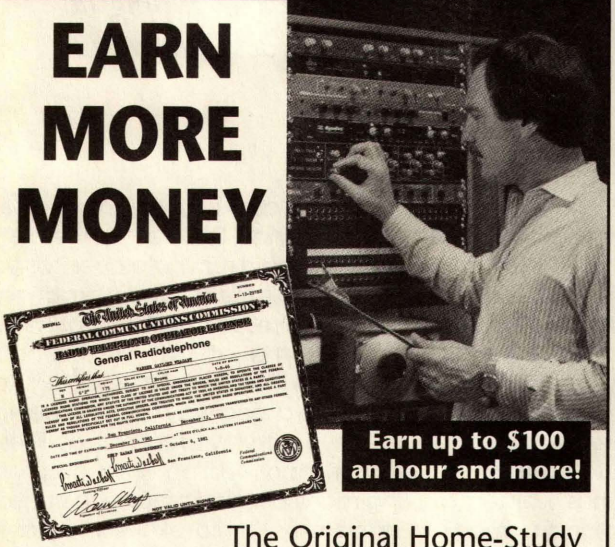

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expander, and then add a stamp here, a PIC there; maybe even an A/D converter on an SPI. Finally, you try to integrate them. To make matters worse, you are adding overhead to your quickly dwindling RAM and ROM on your main processor. You spend more time making the pieces talk than you do making the pieces do their jobs. You have tested the various components, and have tied up a big portion of your resources. But hey! Don't quit–some of it works already.

The point is you find that more and more of your time and creativity is spent making a viable solution. The more time you spend on this solution, the further from your goal you are. The more you think adding something will get you to your goal, the less certain you are of making any real progress towards a final solution. Sometimes you even delude yourself into thinking this is educational.

So far, this scenario has just been about the hardware end. Think about the software tricks you go through to make this mass of hardware function. You have invested a lot of time and effort just getting this tangle into one clump, and you are proud. It really doesn't matter what hoops you're jumping through; you've invested yourself this far, so you tell yourself, "Let's just keep trudging along, it'll all work out, right?" To add insult to injury, you might even be programming delay loops into your poor, over-taxed processor, while you wonder how to simultaneously get function A and B done. Sounds pretty bad so far, huh? Did I mention the endless compiling (including UV erasing), downloading, and debugging cycles? Once you get lost on a road, you forget about the journey. The point is to get to point B, and you are too invested in time and hardware to back up now. You are running in a constrained mode of operation. I suspect you recognize some of my experiences as your own, right? You get so busy doing what you have to that you seldom have time to stop and dream of what would be better.

Fantastic Features

So, let's do some dreaming. Let's think about things a different way by using a series of "What if?" questions. We'll use motion control as a context.

What if you had a small computer board that was designed for motion control? What if that board could perform two-axis control (even using DC brushless motors), as well as controlling each and every transistor in a three-phase H-bridge? What if you could handle six-axis of DC servomotors or even over twenty axes of control using PWM output to R/C servos?

Sounds cool, huh? Bear with me though, because I'm not done. That's just a little portion of the board, and all that can be done in hardware. Yes, I said hardware. We are talking about true "set and forget" hardware; no software follow-up service routines are needed every time a phase change is required for the next cycle to go out, and no interrupts.

That's enough on motion control. Let's take a look at the big picture. Add to the hardware list eight channels of 12-bit A/D, true RS-232, RS-422, SPI, and CAN BUS voltage

regulation, along with more than a dozen uncommitted General Purpose I/O lines. All this with a 40 MIP's DSP core, beyond 2,000,000 high-level instructions-per-second execution speed, and 16,000 high-level instructions in memory. To top it off, this can all be had in a true multi-tasking environment that is 1.2 inches by 3 inches. This is the new product from New Micros, Inc. I had the opportunity to give implementation advice on it. It's called the IsoPod.

IsoMax: The Language

The IsoPod's hardware, which integrates just about every capability you'll ever need, is coupled with a language that was created with behavioral robotics in mind. Randy Dumse created *IsoMax* for robotics and similar applications based on his thirty years experience doing real-time programming. *IsoMax* is a state-machine based language, which exhibits true multi-tasking capabilities. There is exciting work in robotics using state machines to give "intelligence" to robots, so they have clearly defined behavior.

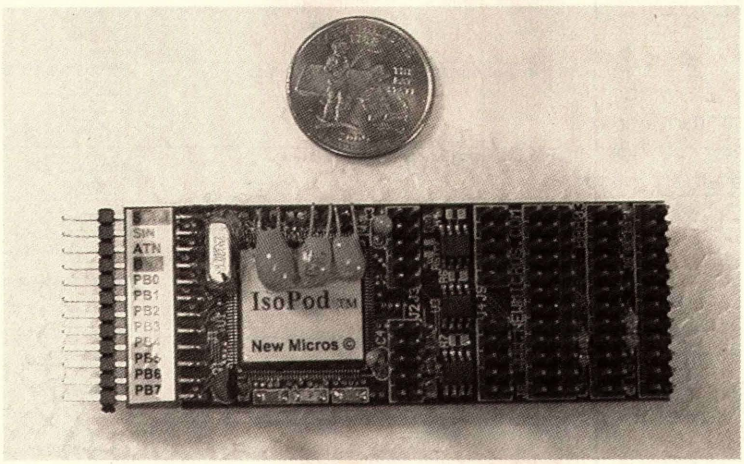
Interestingly, one of the key ideas in the language that makes this new style of programming work is that the language has no backwards-branching words. This keeps all programs flowing forward toward your goals, rather than wasting time doing backward branches. *Isomax* is notoriously efficient, and that is how so much real-time programming can be done with this processor and new language. Do an Internet or library search for "finite state machine" and robotics, and read on, and on.

Isomax is also extremely English like. Here is a typical piece of code, the description of a transition from one state to another:

```
IN-STATE
        FOUND-LEFT-EDGE?
    CONDITION
        LEFT-EDGE-SENSOR OFF?
    CAUSES
        REDLED ON
    THEN-STATE
        FOUND-RIGHT-EDGE?
    TO-HAPPEN
```

On my first real project with the IsoPod, I wanted to *break* it. That is, I wanted to run it hard and fast. So, I dug up six R/C servos and built a routine to cycle all of them back and forth on a sine-wave profile. The project involved lots of floating point math. I did this intentionally, and without regard to efficiency. The IsoPod was able to run through a chain of state machines at 50 Hz without breaking a sweat, so to speak. After all, R/C servos really can't refresh faster than 50 Hz, so I decided to work in the native mode of the hardware. Not killing the controller bugged me, so I kicked it up a notch by setting the machine chain to execute at 500 Hz, and then 5000 Hz. This increase finally bothered it. Bear in mind that this is true multi-tasking running in the background. There was no re-compiling to be done, I just told it to go faster. The IsoPod didn't have time to parse all of the serial ins and outs that it was being asked to do. As a result, the foreground failed. Mind you, the servos were still doing their beautiful dance, though extremely fast. My calculations indicated that the system was running better than 37,000 floating point operations per second. That is fast!

On a later project, I threw together a three-legged robot for kicks. In about three to four hours, I finished my chassis, and had it doing the "paint shaker gait" on my desktop. The addition of feet on the end of the legs allowed me to easily control it. I had all nine servos running simultaneously. The robot was doing robotic Tai Chi: balancing on one foot, setting down and raising the others first under manual control, and later under program control. It was able to walk in a background task, and interactively send it commands in the foreground. The language is extensible by nature, so you can build little tools, as you need them. The ease with which I am able to tackle the projects has inspired me to work on a twenty-servo hexapod, a holography exposure meter shutter/interferometer/diode-laser stabilizer, a mini-sumo with image processing, a traction-control processor for my battlebot, and a robot that balances atop a hard rubber ball.



What if you had a small computer board that was designed for motion control?

Wrapping-Up The Review

As a recap, we have superior integrated hardware capabilities and a language that has been purpose-built for control systems, making it ideal for robotics. What more can you ask for? Well, for one thing, the *IsoMax* language requires a bit of thinking ahead. You should probably get a fairly clear idea of what it is you are trying to do before you tackle the programming aspect. Secondly, *IsoMax* programming is completely unlike anything you are using, or have used so far as programming is concerned. You have to get past the idea of sequential programming. It's like reaching for a cup of coffee: You tell your body to reach with your upper and lower arm, shoulder, wrist and fingers. Most people program how a

pantomime robot would grasp for a cup of coffee: first the upper arm, then the lower arm, then the wrist and fingers.

All of this power and flexibility comes at a cost, however. The more serious issues are:

- The sheer number of connectors is daunting. There are 148 pins on this beast. Most of its physical geometry is devoted to connectors. These are broken up into logical banks, including a "stamp" legacy connector, four comm. Connectors, one bank of R/C servo connectors, and two more for various other functions like A/D, timer pins, and quadrature decoding.

- The language is in a state of flux. I have version 0.2, which will be vastly different from version 0.3. I suspect version 0.4 or 0.5 will be available when this article is published.

- Being a completely new language, there isn't any documentation (except that which is provided by New Micros, Inc.) that covers *IsoMax* at the syntax level.

- Because of the sheer number of connectors, interfacing an extensive project will involve a lot of wires. I am in the process of "twisting" the folks at NMI's collective arms to build a version with two high-density connectors on the back of a carrier chip. A series of mating boards would be purpose-built to accommodate different types of projects, allowing them to accommodate unique connector issues.

The IsoPod will surely lend itself to a huge variety of motion-control projects—particularly ones that use R/C servos, more than one input or output, DC motors, brushless motors, multiple processors, multitasking, extensive floating-point math, or anything with a lot of inherent complexity. All of these types of projects could benefit from a logical programming language that facilitates breaking a task into manageable pieces. By having a language that simplifies hardware interfacing and behavior, and a huge assortment of inputs and outputs, I am guaranteed to be able to devote my time to creative ends. Like I said, I hate to waste time.

Want more information? Contact New Micros, Inc.: write to New Micros, Inc., 1601 Chalk Hill Road, Dallas, Texas 75212, or visit *www.newmicros.com* P

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1. Publication Title: POPTRONICS
2. Publication No.: 1 1 5 2 1 6 - 3 1 6 1 8 1 1
3. Filing Date: 10/01/02
4. Issue Frequency: MONTHLY
5. No. of Issues Published Annually: 12
6. Annual Subscription Price: $24.99
7. Complete Mailing Address of Known Office of Publication (Street, City, County, State, and ZIP+4) (Not Printer): 275 G-MARCUS BLVD., HAUPPAUGE, NY 11788
8. Complete Mailing Address of Headquarters or General Business Office of Publisher (Not Printer): 275 G-MARCUS BLVD., HAUPPAUGE, NY 11788
9. Full Names and Complete Mailing Addresses of Publisher, Editor, and Managing Editor (Do Not Leave Blank)
Publisher (Name and Complete Mailing Address): ADRIA COREN, 275 G-MARCUS BLVD., HAUPPAUGE, NY 11788
Editor (Name and Complete Mailing Address): CHRIS LAMORTE, 275 G-MARCUS BLVD., HAUPPAUGE, NY 11788
Managing Editor (Name and Complete Mailing Address):
10. Owner (If owned by a corporation, its name and address must be stated and also immediately thereafter the names and addresses of stockho or holding 1 percent or more of the total amount of stock. If not owned by a corporation, the names and addresses of the individual owners co owned by a partnership or other unincorporated firm, its name and address as well as that of each individual must be given. If the publication i by a nonprofit organization, its name and address must be stated.) (Do Not Leave Blank.)

Full Name	Complete Mailing Address
GERNSBACK PUBLICATIONS, INC.	275 G- MARCUS BLVD., HAUPPAUGE, NY 11
ADRIA COREN	275 G-MARCUS BLVD., HAUPPAUGE, NY 117

11. Known Bondholders, Mortgagees, and Other Security Holders Owning or Holding 1 Percent or More of Total Amount of Bonds, Mortgages, or O Securities. If none, check here. ☑ None

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12. For completion by nonprofit organizations authorized to mail at special rates. The purpose, function, and nonprofit status of this organization and status for federal income tax purposes: (Check one)
☑ Has Not Changed During Preceding 12 Months
☐ Has Changed During Preceding 12 Months (If changed, publisher must submit explanation of change with this statement)

PS Form 3526, October 1994 (See Instructions on Reverse)

POPTRONICS — JUNE 2002

15. Extent and Nature of Circulation	Average No. Copies Each Issue During Preceding 12 Months	Actual No. Copies of Single Issue Published Nearest to Filing Date
a. Total No. Copies (Net Press Run)	65,416	60,600
b. Paid and/or Requested Circulation (1) Sales Through Dealers and Carriers, Street Vendors, and Counter Sales (Not Mailed)	7,602	8,100
(2) Paid or Requested Mail Subscriptions (Include Advertisers' Proof Copies/Exchange Copies)	37,346	34,733
c. Total Paid and/or Requested Circulation (Sum of 15b(1) and 15b(2))	44,948	42,833
d. Free Distribution by Mail (Samples, Complimentary, and Other Free)	2,011	1,741
e. Free Distribution Outside the Mail (Carriers or Other Means)		
f. Total Free Distribution (Sum of 15d and 15e)	2,011	1,741
g. Total Distribution (Sum of 15c and 15f)	46,960	44,574
h. Copies Not Distributed (1) Office Use, Leftovers, Spoiled	2,021	2,400
(2) Return from News Agents	16,434	13,626
i. Total (Sum of 15g, 15h(1), and 15h(2))	65,416	60,600
Percent Paid and/or Requested Circulation (15c / 15g x 100)		

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Adria Coren Vice President 9/30/02

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PS Form 3526, October 1994 (Reverse)

Q & A

mailto: q&a@gernsback.com

READERS' QUESTIONS, EDITORS' ANSWERS
CONDUCTED BY DEAN HUSTER

What's A "+-Watt?"

I try hard to proof my copy so that oddball things don't happen between my screen and the magazine page. I use *WordPerfect 8* so that I can have a good idea how the final copy will appear, but it has a few quirks that I have to watch. For instance, if I type the standard fraction "½," *WordPerfect* will sling it into a single character that looks great on the page, but falls out to a "+" in my conversion to ASCII to send to the Mother Ship where the editors live. So, in the October 2002 column, whenever you saw "+-watt", it was really supposed to be "½-watt." I always run the column through *WordStar 6.0* for my final conversion to ASCII since I can't seem to get a lot of the *WordPerfect* "fluff" out of the data when I save the file using its ASCII conversion. Maybe I should write the column using *WordStar* (the all-time world's greatest word processor) to avoid all the hassle and not worry about what the column might look like.

Need a Lift, Buddy?

Q *I've been involved in maintaining a British Coventry Climax forklift, circa 1950's, for 8 years. It's a prime example of excellent British workmanship, mechanically sound, and the drivers love it. What killed it is the lack of electrical parts, especially the contactors and/or contact kits for the contactors. I've exhausted all sources of parts known to me and I'm thinking to replace all of the contactors with transistor modules. Considering what we paid for the last set of contacts, it's a bargain either way. But I have a dilemma: Should I go for MOSFET modules or stick to plain Darlingtons? We're talking about 36 volts at about 100 amps, one main 5-hp drive motor plus a 1-hp pump. Price difference is irrelevant. I'm just worried about inrush-starting currents and voltage spikes. Which way should I go?—M.J., via e-mail*

A I wouldn't presume to be able to find other sources of replacement parts for the lift, assuming that you're the expert on the subject and have already run all the possible channels. As an alternative, it may be that we have some readers who are professional forklift technicians who might be able to provide you with replacement parts sources just for the extra information even though you're contemplating the electronic-module substitution. I assume that the manufacturer is either out of business or has long ago ceased support for this model. You might try posting a request for a parts source on the "Everyday Practical Electronics" forum just to see if you can obtain some "fallback" positions for the future. EPE is an electronics hobbyist publication in the U.K., similar to **Poptronics**.

My choice would be the MOSFET modules if I had to select. They'll have lower "on" resistance, giving you more efficiency for these high-current, battery-operated items. It appears that you're considering commercial modules, so as along as they're designed for applications such as yours and you select them to handle the starting current of the motors, they should handle the voltage spikes without a problem.

I don't know the size of your business, but all nostalgia and operator love aside, it might be in the company's best interest to retire the lift anyway. Does a lift made in the 50s meet current *O*ccupational *S*afety and *H*ealth *A*dministration (OSHA) safety requirements? If not, keeping the lift in service could be inviting some liability issues to visit you. As you know, modern lifts have roll bars, safety cages, safety switches, back-up alarms, warning lights, and other gizmos that may be part of an OSHA-required safety package into which the old lift cannot be grandfathered.

Resistive Physics

Q *In a physics lab back in the 60s, I had the task of measuring a batch of 5% resistors using a Wheatstone bridge. The result was the classic bell-shaped curve; however, the center of the distribution was well off the center value! The moral is: although the manufacturer is obligated to ensure all the resistors fall within tolerance, he has no obligation to center the distribution in any given batch.—D. H.,via e-mail*

A I'll bet a dollar to a doughnut (which may not be an attractive wager these days) that the center of the distribution was high. Those resistor values were probably on-target when they left the manufacturing line and moved afterward. If that's the way they came from the factory when new, they were already well on the way to becoming out-of-tolerance before their time. It's questionable that you were working with resistors that were relatively fresh from the manufacturer, considering that schools back then weren't known for having the most up-to-date equipment or the limitless resources that some schools appear to have these days.

As I reread October 2002's "Q&A" column, where I discussed those crawling resistor values, I seem to indicate that as the values of a batch shift, they would fall into the standard bell curve of value distribution. Odds are they would. I am just not sure that a particular resistor would hold its position in its original curve against all the other resistors on a curve 10 years later, each resistor shifting by the same percentage at the same time. Also, I would expect the shape of the curve to change, flattening out somewhat with the age of the components as the values begin to get a little wilder.

Back in those days, you and I had to trudge through the labor of rebalancing that Wheatstone bridge for each resistor. One of today's 4-terminal digital multimeters would have made that lab experiment a fifteen-minute task rather than a four-hour ordeal; and an automated test set-up would have shortened it to five minutes and provided a printout and full analysis of the results (if you don't include the programming time). Although most folks trust modern digital equipment to a fault, it's a

fact that a Wheatstone bridge is still used by standards labs for comparing standard resistors because of its greater accuracy and precision.

Tach-Plus Parts Search

Q *I would like to know where I can get some of the parts to build the Tach-Plus Digital Tachometer in the September 2002 issue. I can't find the 82-mH metal-encapsulated coil, the LCD display, IR emitter, and IR detector at any of the normal suppliers I deal with.—T.P., via e-mail*

A I contacted Robert Dee, the author of that article, who graciously supplied me with sources for those parts which were inadvertently omitted from that article. The LTR-516AD IR detector is Digi-Key part number 160-1032-ND and the OED-EL-8L IR receiver is Digi-Key part number 67-1000-ND. The 82-mH chokes were procured from Mouser Electronics, their catalog number 434-02-823J, as was the LCD display, catalog number 628-L167100J.

Robert also mentioned that the computer program that he uses to build the code for the processor is *AVR Studio*, which is a free download from the Atmel Internet site. Once on the Atmel home page, click on "Software & Shareware" at the left side, then click on *AVR 8-bit RISC* at the right on the next page. The AVR chips are programmed using Atmel's STK500 board. The complete starter kit is available from Digi-Key, their part number ATSTK500-ND for $79.00.

Robert also mentions that some builders had trouble finding the RadioShack case. Their part number for that case has changed from 270-213 to 270-0213. He says that you can also use Pac Tec # K-HP-9VB or Mouser number 616-62006 for a case.

Robert now has a complete kit of parts for the Digi-Tach available for $69.95 + $7 shipping. Digi-Key is at *www.digikey.com*, Mouser is at *www.mouser.com*, and Atmel is at *www.atmel.com*.

Stale Chips

Q *Have you heard of a ULN3701 integrated circuit? I found the IC in a schematic, but am having trouble locating the part. I tried going to the IC Master Web page and even that came up with nothing.—S.E., via e-mail*

A No, I haven't heard of it. For that matter, considering that there are a half-billion different chips out there, the ones that I've heard of don't even scratch the surface! It appears that it's an older part that's either no longer manufactured or just not carried by the mainline distributors. I looked in one of my cross-references and found that ULN3701Z has a cross-reference to a replacement semiconductor, the NTE1232, ECG1232 or SK3852. NTE parts are available from several sources including ABRA Electronics; their part number is NTA1232 for $7.76. ABRA can be contacted by phone at 800-717-2272 or via the Internet at *www.abra-electronics.com*.

According to the NTE book, the chip is an 8-watt audio-power amplifier for car-radio applications. IC Master is okay for newer parts, but when all else fails, often you can at least find a substitute using one of the replacement semiconductor companies.

Newbie Help

Q *I'm a retired mechanical engineer and have taken up electronics as a serious hobby. I have taken three courses on the subject at our community college. I have a 'scope, function generator, cabinets full of ICs, resistors, caps, etc., and am enjoying myself.*

I recently became interested in microphones and their amplifier circuits. Using an inexpensive electret-mic capsule, I built this pre-amp and amplifier from a published source. It works reasonably well, but is prone to oscillation if the input to the amplifier is too high.

I have some specific questions about the amplifier circuit. What changes in the output from the amplifier are necessary to change the 8-ohm speaker to a 4- or 16-ohm one, or to use a headset like the ones used on portable cassette players? I haven't tried this since I could blow them out! There seems to be capacitors all over the place, and they seem to be for purposes other than preventing DC from passing. Note for example back-to-back C1 and C2 in the circuit. Is there any at least partial explanation for their copious use?

Also, I am interested in getting deeper into projects of this type, but nowhere can I find any educational material on the "wherefore and whyfore" on these circuits. I have many textbooks on digital and integrated circuits, as well as many project and circuit books that have some circuits but no explanations. I would really like to start my future endeavors with gaining the knowledge of how these circuits work and where to find more sophisticated circuits.

Do you know of any books, more or less primers rather than engineering texts, that might be helpful? Being out of print doesn't matter, as there are so many good used-book sources on the Web. —W.C., Walnut Creek, CA

A Rest assured that we're all newbies in this hobby. There's so much out there that we can't know it all, so we hobbyists tend to specialize. You'll note that I don't mess around with PICs in this column, but I love the digital and analog IC circuits.

You have the right start on books for your new hobby. Textbooks on specific subjects and the project books are

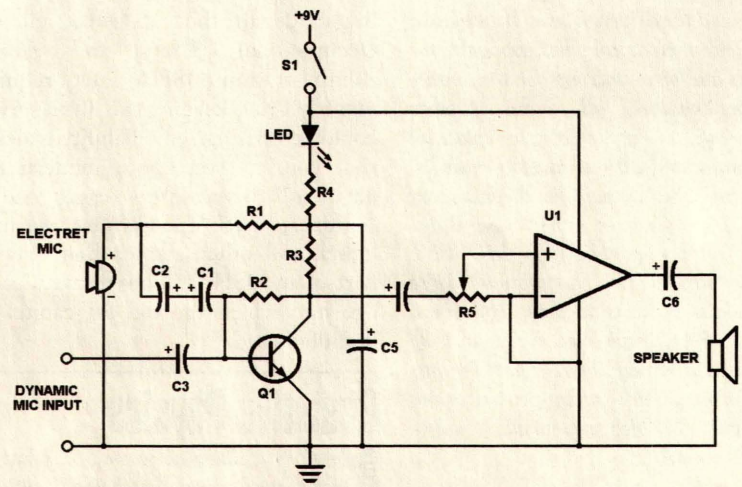

Fig. 1. This "generic" microphone pre-amp and output-amplifier circuit uses capacitors generously throughout the circuit for varying reasons.

wonderful. If you're interested in hunting down out-of-print stuff, I would suggest you try to find copies of Heathkit courses, especially their "design series." Heath no longer publishes any of those. Specifically, "Operational Amplifiers" is one of their best. It was written by Howard Berlin as "Operational Amplifiers with Experiments" published by Howard W. Sams. I think it's still in print. Also, the Heathkit "Active Filters" and "IC Timer" courses were good. The filters course and timers course were also published as Sams books and you still may find those somewhere. I believe Berlin wrote the filters course and Walt Jung wrote the timers course.

Contact several of the IC manufacturers and get the data books they have for their general-purpose linear devices and digital chips. The data books not only have the device specifications, but also a lot of circuits and tips for making the circuits work. I learned nearly all of what I know about digital from National Semiconductor data books. You just look up a chip that you don't know anything about and start reading about it, buy a few, and play with them. It has been pretty much the same with analog electronics for me. And never throw away a data book. Although they go out of date as far as current production devices go, they still cover a lot of what is being sold in the hobbyist arenas and what you'll find on older equipment that you procure.

There are several magazines that you can subscribe to for free, but they're targeted to electronics professionals. You may qualify if you "fill out the cards right," if you get my drift. One of my favorites is *Electronic Design* published by Penton. Other magazines will cost you—you've already found this one. A competing magazine to **Poptronics** is *Nuts and Volts* where TJ Byers has a similar column to mine. He's a lot smarter than I am, but I'm a heck of a lot cuter. If you want to pay the shipping costs, there are several English language magazines from the U.K. and Australia. I'm going to have an upcoming item on that in a future column after I pull together all of the resources. Several publishers have sent me copies of their magazines so that I can give you first-hand coverage of their style and content.

Your circuit is shown in Fig. 1. Since it came from copyrighted sources, but is general enough in design to be public domain, I've eliminated the component values since all we're discussing is why certain components are there. The amplifier is pretty forgiving of changes in load impedance. I don't know that you'd have to go as low as 4 ohms for a speaker since the small ones that the amp is capable of driving are usually 8 ohms. The cassette player headsets are usually 32 ohms and the circuit should drive them just fine.

Every single one of the caps in the circuit is for blocking DC while letting the AC pass. C3 is the input-coupling cap and keeps the low DC resistance of the dynamic microphone from wrecking the DC bias on the transistor base. Capacitors C1 and C2, originally 10 microfarads each, are put in the circuit in this way because the designer has the idea that it creates a non-polarized capacitor from two electrolytic caps. I don't see the point of needing a non-polarized cap here anyway because the base of Q1 will be about +0.7 volts and the positive end of the microphone will be much higher than that. I'd eliminate C2, connecting the positive end of C1 directly to the junction of the mic and

HOW TO GET INFORMATION ABOUT ELECTRONICS

On the Internet: See our Web site at *www.poptronics.com* for information and files relating to **Poptronics** and our former magazines (**Electronics Now** and **Popular Electronics**) and links to other useful sites.

To discuss electronics with your fellow enthusiasts, visit the newsgroups *sci.electronics.repair, sci.electronics.components, sci.electronics.design,* and *rec.radio.amateur.homebrew.* "For sale" messages are permitted only in *rec.radio.swap* and *misc.industry.electronics.marketplace.*

Many electronic component manufacturers have Web pages; see the directory at *www.hitex.com/chipdir/*, or try addresses such as *www.ti.com* and *www.motorola.com* (substituting any company's name or abbreviation as appropriate). Many IC data sheets can be viewed online: *www.questlink.com* features IC data sheets and gives you the ability to buy many of the ICs in small quantities using a credit card. You can also get detailed IC information from *www.icmaster.com*, which is now free of charge although it formerly required a subscription. Extensive information about how to repair consumer electronic devices and computers can be found at *www.repair faq.org*

Books: Several good introductory electronics books are available at RadioShack, including one on building power supplies.

An excellent general electronics textbook is *The Art of Electronics*, by Paul Horowitz and Winfield Hill, available from the publisher (Cambridge University Press, 800-872-7423) or on special order through any bookstore. Its 1125 pages are full of information on how to build working circuits, with a minimum of mathematics.

Also indispensable is *The ARRL Handbook for Radio Amateurs*, comprising over 1000 pages of theory, radio circuits, and ready-to-build projects, available from the American Radio Relay League, Newington, CT 06111, and from ham-radio equipment dealers.

Back issues: Copies of back issues of and past articles in **Electronics Now, Popular Electronics**, and **Poptronics** can be ordered on an "as available basis" from Claggk, Inc., Reprint Department, P.O. Box 12162, Hauppauge, NY 11788; Tel: 631-592-6721. To ensure receipt of the correct material, readers must supply complete information on the article or issue that they wish to buy.

Poptronics and many other magazines are indexed in the *Reader's Guide to Periodical Literature*, available at your public library. Copies of articles in other magazines can be obtained through your public library's interlibrary loan service; expect to pay about 30 cents a page.

Service manuals: Manuals for radios, TVs, VCRs, audio equipment, and some computers are available from Howard W. Sams & Co., Indianapolis, IN 46214; (800-428-7267). The free Sams catalog also lists addresses of manufacturers and parts dealers. Even if an item isn't listed in the catalog, it pays to call Sams; they may have a schematic on file which they can copy for you.

Manuals for older test equipment and ham radio gear are available from Hi Manuals, PO Box 802, Council Bluffs, IA 51502, and Manuals Plus, 130 N. Cutler Dr., N. Salt Lake, UT 84054.

Replacement semiconductors: Replacement transistors, ICs, and other semiconductors, marketed by Philips ECG, NTE, and Thomson (SK), are available through most parts dealers (including RadioShack on special order). The ECG, NTE, and SK lines contain a few hundred parts that substitute for many thousands of others; a directory (supplied as a large book and on diskette) tells you which one to use. NTE numbers usually match ECG; SK numbers are different.

Remember that the "2S" in a Japanese type number is usually omitted; a transistor marked D945 is actually a 2SD945.

Hamfests (swap meets) and local organizations: These can be located by writing to the American Radio Relay League, Newington, CT 06111; (*www.arrl.org*). A hamfest is an excellent place to pick up used test equipment, older parts, and other items at bargain prices, as well as to meet your fellow electronics enthusiasts—both amateur and professional.

R1, and then change the value of C2 to 4.7 microfarads. Capacitor C5 decouples the power supply. Not only does R4 provide current limiting for the LED, but it also is part of the decoupling circuit with C5, forming a low-pass filter that keeps fluctuations from either the pre-amp or the output amp from interfering with each other. Capacitor C4 couples the audio across to unlike DC levels between the collector of Q1 and the input to the output amplifier. Capacitor C6 isolates the low DC resistance of the speaker from the output of the amplifier which probably sits at half of the supply voltage. A direct connection there would allow DC to run through the speaker.

You'll find that a lot of these audio IC amplifiers will have a few extra capacitors around them. Without the caps or with caps of the wrong value, they're often unstable and will oscillate.

Disappearing Optoelectronics

Q *I'm in need of a TIL32 photodiode and TIL78 phototransistor for the Heathkit ID-4001 weather station. I have been unable to find these parts.—L.F., North Platte, NE*

A Both Texas Instruments, the maker of the TIL series, and Motorola have stopped making all of those wonderful optoelectronics components, and I don't know why. TI has sold the bulk of their line, but their Technical Support department has told me that there is an Internet page you can check out to find out to which company each part number was sold. It's at *www-mkt.sc.ti.com/internal/docs/MSP/opto/licensed.htm*. Watch out for that hyphen (vs. a period) after the "*www.*"

Since you're working with a Heathkit, check out Tom's Heathkit forum on the Internet at *http://pluto.beseen.com/boardroom/q/51675/*. It may be that some of the individuals there may be able to help you with either a source or a substitute. I'd have done a better job digging and digging to find the specifications and finding a Panasonic or Omron sub, but (sob!) all of my data books are currently in storage where I can't get to them. Those devices were popular enough that maybe we have some readers that can help out here.

Electronic Etch-a-Sketch

Q *My young son was playing around with some magnets around our television and now we have these awful off-colored splotches around the edge of the picture and off-color people. How do I get rid of this? I hope it isn't permanent.—S.C., via e-mail*

A Eventually, most people, especially the curious ones, discover in a bad way the adorable Etch-a-Sketch qualities of a color TV or computer monitor when they start playing with permanent magnets around them. The electron beams within the picture tube are normally deflected by the magnetic fields of the deflection yoke around the neck of the tube. The permanent magnets have magnetized the front of the shadow mask area of the tube and pulls the otherwise perfectly-aligned electron beam off-course so that they don't hit the colors they're supposed to hit if they hit any at all.

It may be that the spot will go away by itself after several cycles of turning the TV off and on. Every color TV has a degaussing coil around the picture tube that when first turned on, has a decreasing-voltage AC signal that demagnetizes the picture tube to keep the colors pure. Normal moving of the TV, the earth's magnetic field, and playing with magnets cause these anomalies. A permanent magnet that goofs things up is a little more difficult for this weak degaussing field to "erase," but it may eventually go away, especially if the spot is near the edge. The TV must be turned off and remain off for at least fifteen minutes before turning it back on or the coil won't go through its cycle. It's often controlled by a thermistor in series with it across the AC line and if the thermistor is hot (as it is with the set running), it's a high resistance and the coil will have no field. The thermistor has to cool down first.

Some televisions or monitors may have a manually-activated degaussing button you can press repeatedly to clear up the problem. If the splotches don't go away on their own through these slightly extended efforts, you'll have to get more drastic.

You can buy a degaussing coil that may do the trick. Or you can hunt around for someone who has one of the old bulk-tape erasers. Those work even better because they have a stronger field. The idea is that you have an AC signal that demagnetizes the picture tube. Plug the degaussing coil into an outlet and slowly move it in front of the face of the television, concentrating around the area around the offending spots. Then SLOWLY bring the coil far away from the tube before turning it off so that you don't get a final magnetic spike that will remagnetize the tube.

You have to be more careful with the bulk-tape eraser. Again, turn it on away from the tube and then bring it close enough so that its field affects the picture strongly, moving it slowly around near the face of the tube. This field is strong enough that you don't want to get too close to the tube so that you don't wreck the shadow-mask structure. Then pull the eraser back slowly until you're several feet away from the TV before you turn it off. If it gets turned off too close to the tube, it can remagnetize the tube in funny spots and you'll have to do it all over again. I didn't see a degaussing coil in the big RadioShack catalog. MCM Electronics (*www.mcmelectronics.com* or 800-543-4330) or Dalbani (*www.dalbani.com* or 800-325-2264) may have one since they specialize more in consumer product repair. I've even seen them in the past at discount stores that are home-based in Bentonville, Arkansas.

Be very, very careful with rare earth permanent magnets, such as those you remove from computer hard drives, when you're around picture tubes. Two of them snapping together can pinch a blood blister onto your fingers. That'll go away. One of them can do permanent damage to a picture tube. P

Writing to Q&A

As always, we welcome your questions. Please be sure to include:

(1) plenty of background material,

(2) your full name and address on the letter (not just the envelope),

(3) and a complete diagram, if asking about a circuit; and

(4) type your letter or write neatly.

Send questions to Q&A, **Poptronics**, 275-G Marcus Blvd., Hauppauge, NY 11788 or to *q&a@gernsback.com*, but do not expect an immediate reply in these pages (because of our backlog). We regret that we cannot give personal replies. Please no graphics files larger than 100K.

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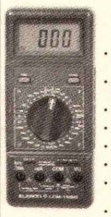

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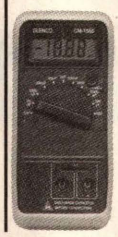

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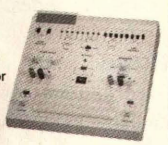

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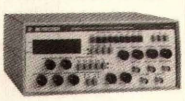

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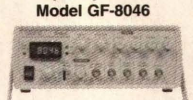

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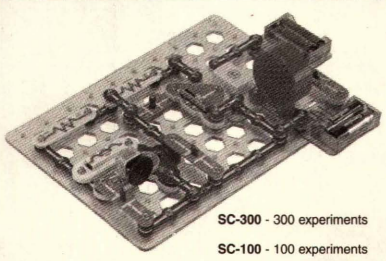

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TJ BYERS

PIC-Controlled ISD ChipCorder Makes Model RR Train Sounds

You may notice that the theme for this month's issue is sound—MIDI sounds, to be exact. Not to be the odd man out, after learning of this plot I dug through my bag of tricks and came up with a PIC-sound project based on the popular ISD2560-ChipCorder chip. Unlike the MIDI, which generates its own sounds, the ChipCorder records sounds and plays them back like an audio-cassette recorder.

The ISD2500 series comes in storage times of 60 (ISD2560), 75 (ISD2575), 90 (ISD2590), and 120 (ISD25120) seconds. Recordings are stored in on-board EEPROM memory directly without the compression techniques used by other methods (like MP3) to provide a faithful reproduction of voice, music, tones and sound effects. The chip includes a microphone input, with *a*utomatic *g*ain *c*ontrol (AGC), and an audio output.

The beauty of the ISD2500 chip is its ability to record individual "messages" consecutively in the memory space. Take the ISD2560, for example. In this space you can record two 30-second messages, three 20-second messages, six 10-second messages, or any mix thereof. The messages can be played back in the order recorded, in a never-ending loop, or individually using one of the five message playback modes.

PIC Power

In addition to ease of use via push buttons, the ISD2500 has a microcontroller interface that permits control of all facets of the chip's playback modes and individual message selection. Both are accessed through address and control pins that interface to the ports of a

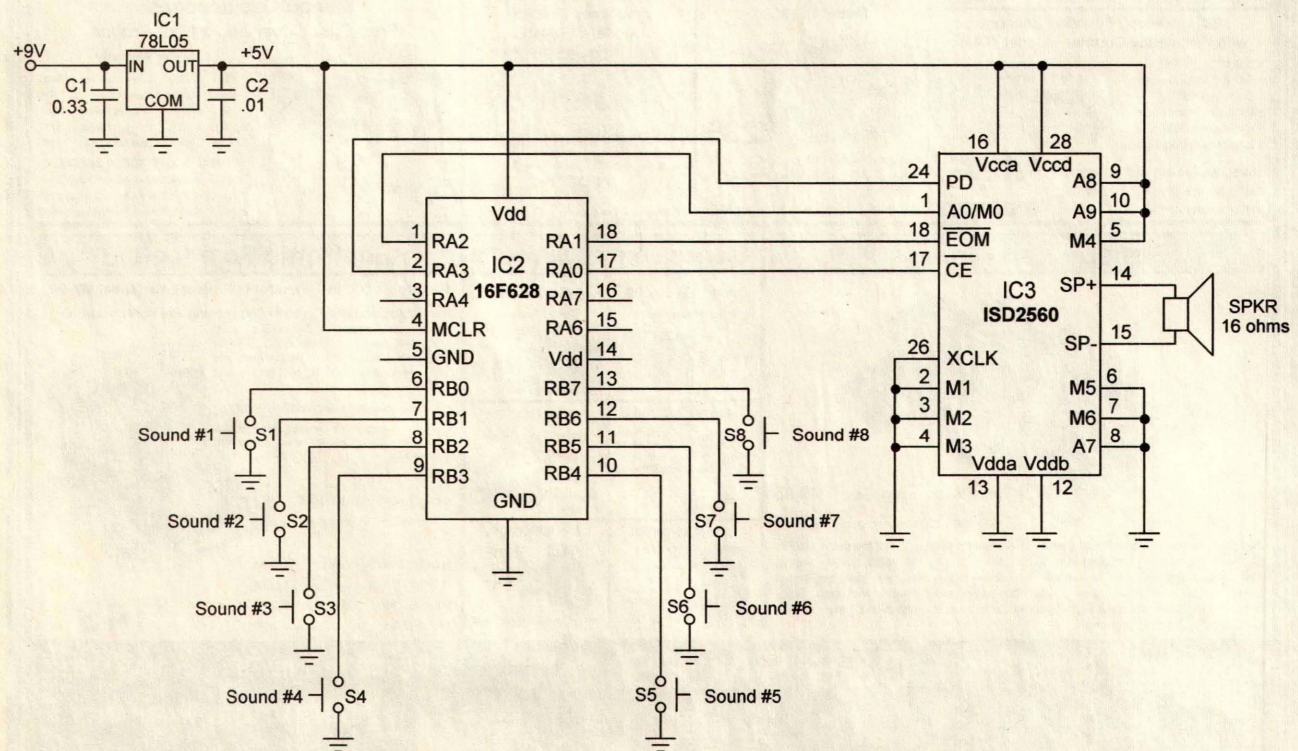


Fig. 1. The ISD2560 ChipCorder sound chip interfaces easily with the 16F628 PIC. Each push button represents a different train sound.

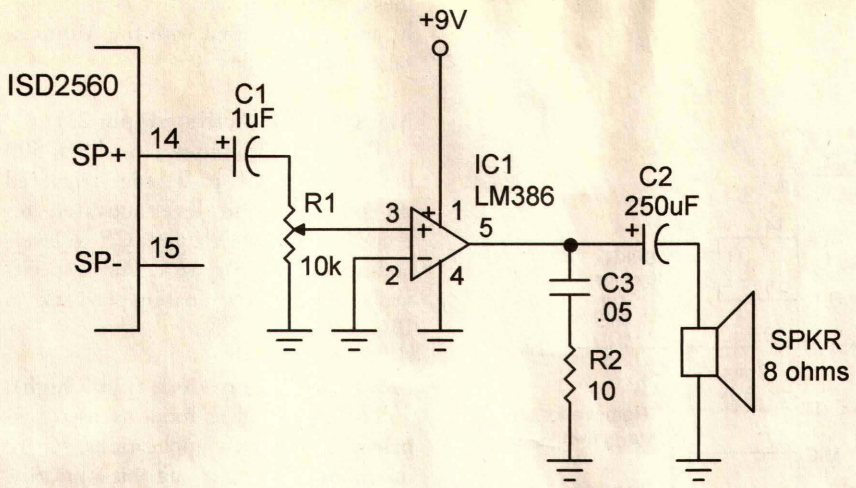


Fig. 2. The audio output of the ISD2560 is a weak 12.5-mW. This circuit boosts the volume by 20 fold. For louder sounds, place a 10-µF capacitor across pins 1 and 8.

PARTS LIST FOR THE 16F628 ISD CONTROLLER

SEMICONDUCTORS
IC1—78L05
IC2—16F628
IC3—ISD2560

CAPACITORS
C1—0.33-µF
C2—.01-µF

ADDITIONAL PARTS AND MATERIALS
S1-S8—SPST momentary push-button switch
SPKR—16-ohm speaker
9-volt battery with connector

microcontroller, and is especially PIC friendly. The PIC can be programmed to perform a variety of tasks, including message assembly, message concatenation, defined-message segmentation, and message management.

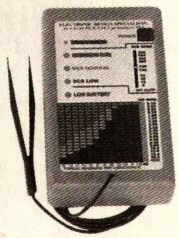
Sounds are recorded in the internal EEPROM using a beginning memory address and an *E*nd *O*f *M*essage (EOM) marker. They are recorded consecutively, with the address of the second message following the end of the first message, and so forth.

Individual messages can be selected for playback by setting the address pins high or low. The second way to play back the message(s) is by using one of the operational modes. However, the address lines and operational mode bits share the same pins. When pins A8 and A9 are tied high (V_{CC}), the pins are interpreted as mode bits and not address bits. This is the configuration recommended for PIC use, see Fig. 1. The modes are as follows.

M0: Message Cueing (pin 1 high)

Message cueing allows the user to skip through messages without knowing the actual physical address of each message (direct-address access requires this information). The number of messages to be skipped before playing a message is

The Standard for checking Capacitors in-circuit



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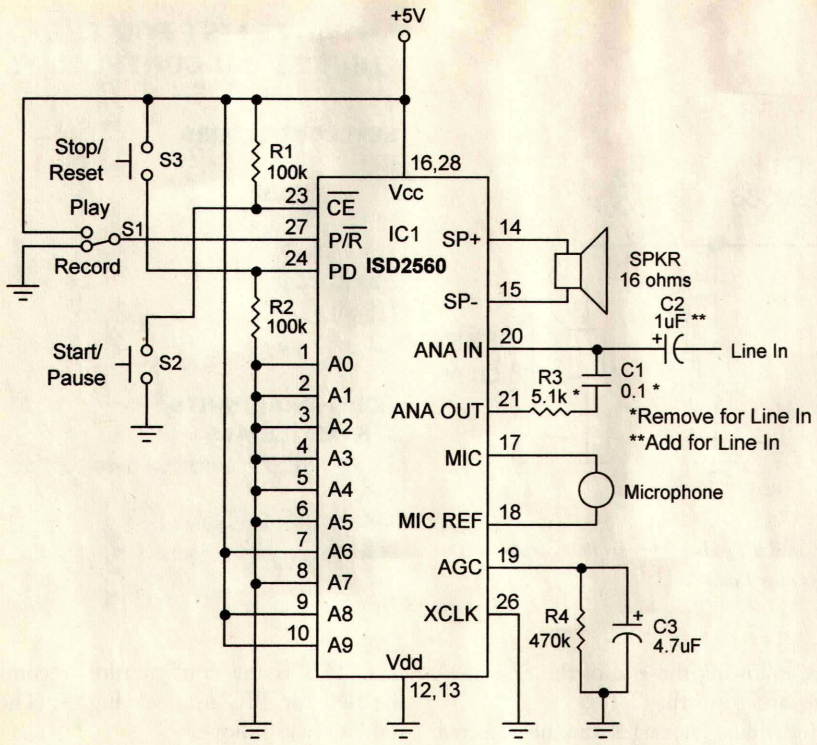

Fig. 3. This is a simple, push-button ISD2500 playback/recorder. The circuit is shown wired for a dynamic microphone input; for Line In recording alter the circuit as indicated.

determined by the start/pause input (CE, pin 23).

M1: Delete EOM Markers (pin 2 high)

When this mode is selected, the sequentially-recorded messages are played back as one continuous message.

M2: Unused (pin 3)

M3: Message looping (pin 4 high)

The message-looping mode provides continuous, repeated playback of a selected message. A message can completely fill the ISD2500 memory space, or be any part of it, and will loop from beginning to end over and again. This mode can also be used in conjunction with M1 to concatenate the individual messages into one long for message looping.

M4: Consecutive Addressing (pin 5 high)

During normal operations, the address pointer is reset when a message is played through an EOM marker. The consecutive-addressing mode allows messages to be played back consecutively, and is often used with the M0 message-cueing mode.

M5: CE Level Activated (pin 23)

The default mode for ISD2500 devices is for CE to be edge-triggered on playback and level-activated on record. Mode M5 changes CE to level-activated during playback. This is specifically useful for terminating playback via PIC control.

M6: Push-Button Mode (pin 7 high)

The push-button mode is used primarily in low-cost applications, where minimum external circuitry is a priority. In fact, this configuration is often used for one-time recording of ISD2500 chips.

Project: Model RR Train Sounds

As always, you'll learn through hands-on experience by building a project. For this project I selected an item that will please any model RR enthusiast—real train sounds. Eight train sounds are recorded into an ISD2560 and played back from an "engineer's" control panel using push-button or toggle switches.

No, I'm not using the push-button mode, but I am using switches to select the individual sounds for playback. For this design, I'm working in the M0 message-cueing mode, where I scan through the messages until I come to the one I want to play back. The push buttons tell the PIC how many messages to skip before it starts playback. It does this by counting the number of EOM markers on pin 25. Each time the ISD2560 reaches the end of a message, the EOM pin goes low for about 12mS. See Listing 1 for details.

The push-button buffer is first cleared of values, then the program loops in search of a pushed button. This is done by monitoring the Zero flag bit, which remains high until a button is pressed. A delay routine prevents false triggering from switch bounce.

When a valid push button is detected, the value is stored in a *Message Number* (MsgNum) register. If that value is zero (0), the CE output is strobed low and the first message plays. If it is higher than zero, the PIC waits for an EOM marker. Each time an EOM marker appears on the RA1 input, the routine subtracts one (1) from the MsgNum number. When it reaches zero, the CE line is pulled low and the selected message plays.

PARTS LIST FOR THE SERIES ISD2500 RECORDER

SEMICONDUCTORS
IC1—ISD2560

RESISTORS
R1—100k
R2—100k
R3—5.1k*
R4—470k

CAPACITORS
C1—0.1-µF*
C2—1-µF*
C3—4.7-µF

ADDITIONAL PARTS AND MATERIALS
S1—SPDT toggle switch
S2—SPST momentary push-button switch
S3—SPST momentary push-button switch
SPKR—16-ohm speaker
Microphone—dynamic mike

*Note: For Line In recording, remove R3 and C1; add C2

The number of messages was purposely limited to eight, the number of available Port B inputs. However, that number can be increased using binary multiplexing. For example, the eight lines can be reduced to three using the sequence 000, 001, 010, 011, and so forth. Adding a fourth pin increases the number of message selections to 16, five lines is 32 messages, on up to 256 choices. Of course, be prepared to increase the recording time of the ISD2500. For very long recordings, the ISD2500 can be cascaded; details are shown in the ISD manual at *www.isd.com/products/isd_products/chipcorder/applicationinfo/apin09.pdf*.

Here are a few things to bear in mind when working with this circuit. The operational and direct-address modes are determined by A8 and A9, which are pulled high for the operational mode, low for the direct address mode. The operational and direct address modes aren't compatible and can't be used simultaneously. Connecting the address lines directly to a microcontroller bus is not recommended; address lines should be externally latched using semiconductor or mechanical switches, which can be microcontroller driven.

Never ground either of the speaker outputs, or connect them in parallel with other ISD2500 devices. A single pin may be used alone for grounded output applications provided there is a coupling capacitor between the SP pin and the grounded load. Note that the power output is reduced by one-fourth in this configuration. Using differential outputs, the speaker driver is capable of delivering 12.5mW into a 16-ohm load. An amplifier using an LM386 IC is shown in Fig. 2. For higher gain, connect a 10-µF capacitor across pins 1 (+) and 8.

That's all I have time for this month, but I'm sure you can find plenty to keep you busy until next time. Til then, have fun and stay warm. P

Series ISD2500 Recorder

There is a file of eight train sounds posted on our Web site (TK) under the name TRAIN_SOUNDS.ZIP which need to be transferred to your blank ISD2560. To do that you need a playback/record circuit, like the one shown below.

The circuit is wired for recording from a dynamic microphone. If you wish to record from the Line Out of your sound system, remove the 0.1 cap and 5.1-K resistor, and add the 1-µF coupling capacitor. Reduce the Line In voltage to about 70mV to avoid clipping of the signal. If you don't have an AC millivoltmeter (and who does), this is done through trial and error. Using a potentiometer, adjust the volume, record your sounds, then playback and listen. If it sounds distorted, reduce the volume and try again. Once the volume is set, it doesn't need to be readjusted as long as you use the same signal source.

To record sounds:

1. Select the Record mode using S1
2. Press Start/Pause switch S2
3. Begin record
4. To pause record, press Start/Pause switch S2
5. To continue recording, press Start/Pause switch S2
6. Press Stop/Reset switch S3 to end recording session

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PARTS LIST FOR THE LM386 AMPLIFIER

SEMICONDUCTORS
IC1—LM386

RESISTORS
R1—10,000-ohms potentiometer
R2—10-ohms

CAPACITORS
C1—1-µF
C2—250-µF
C3—.05-µF

ADDITIONAL PARTS AND MATERIALS
SPKR—8-ohm speaker

A kit of the above parts is available for $TK from Futurlec, 1133 Broadway, Suite 706, New York, NY 10010 (*www.futurlec.com*) and includes a programmed PIC. A programmed PIC is also available separately for $1.

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SAM GOLDWASSER

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Hacking The Kodak MAX (And Similar) Electronic Flash Units

The electronic flash units from disposable-packet 35-mm and Advantix cameras are among the most useful little gadgets, available for essentially nothing. They can be used as electronic flashes, single-short and repeating strobes, and the basis of DC-power supplies up to 350 V or so running from a 1.5-volt alkaline cell or a battery eliminator. They can easily be adapted to computer control. Over a year ago, "Service Clinic" covered the basics of electronic-flash operation and repair. This month, I'll show how some of the things that can be done with one particular flash unit from a common disposable or single-use camera—the Kodak MAX. Most other brands are very similar.

Safety

Despite being powered from a single 1.5-volt alkaline cell, the energy-storage capacitor can hold a potentially lethal charge for days on the unmodified circuit. ALWAYS confirm that it is discharged fully before touching anything. Further note that the many of these flash circuits automatically recharge to be ready for another shot, so triggering them just means that the capacitor will be fully recharged in a couple of seconds. See the additional safety guidelines in previous "Service Clinics."

The MAX Flash Circuit

The Kodak MAX single-use 35-mm pocket camera, with flash, has a flash unit that runs from a single 1.5 -volt alkaline cell and generates over 300 V_{DC} for the flash tube (see Figure 1). See the previous "Service Clinic" series on electronic flash and strobes for more

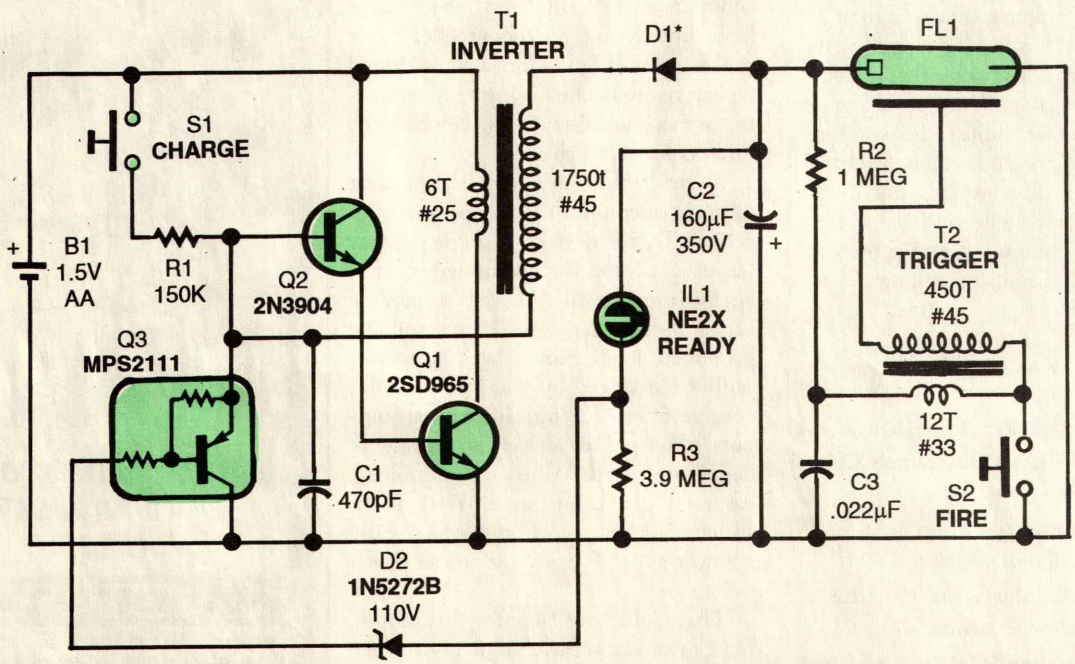

Fig. 1. The Kodak MAX single-use 35-mm pocket camera, with flash, has a flash unit that runs from a single 1.5 -volt alkaline cell and generates over 300 V_{DC} for the flash tube.

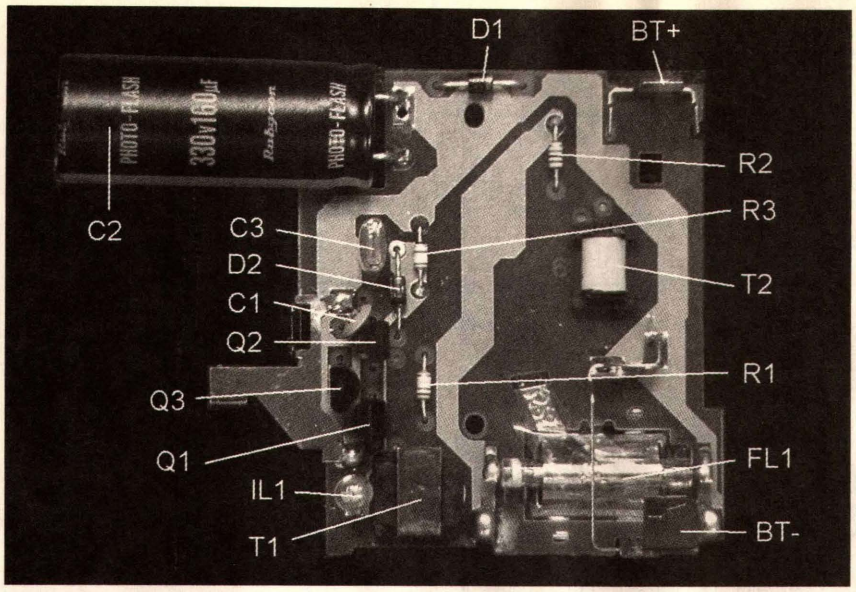

Fig.2. This photo shows the top view of the flash circuit.

information on this technology. A single-transistor oscillator drives a step-up transformer, whose output is rectified to charge the main energy-storage capacitor and trigger capacitor.

The Kodak MAX circuit has a voltage limiter (regulator) that disables the inverter when the voltage on the energy-storage capacitor, C1, exceeds about 300 V_{DC}. It is only necessary to press and release the CHARGE button since the inverter continues to run until fully charged and holding the CHARGE button in all day would do no harm since the regulator cuts it off!

In addition, this unit automatically recharges after firing, so the camera will be ready for another shot without the user having to think about it.

For instructions on disassembling Kodak MAX cameras, see Don's Hack Kodak MAX to Strobe Page at *http://www.misty.com/people/don/kmax-hack.html.*

The major parts present in these units include:

Chopper transistor—high-gain power transistor to drive the inverter.

Inverter transformer—Generates the 300+ V_{DC} to charge the energy-storage capacitor.

Energy storage capacitor—120- to 160-µF, 350 V, photoflash-rated (rapid discharge) electrolytic.

Neon (200-volt breakdown) **ready indicator.**

Trigger transformer—generates a 4- to 8 -kV pulse to fire the xenon tube from a small 150- to 300-V capacitor discharge.

Xenon flashtube.

Also, a nearly-fresh alkaline cell (unless the people at the photo place grabbed that before you!).

All newer Kodak disposable cameras, including the "Funsaver Sure Flash," appear to use a similar, if not identical, circuit. Apparently, Advantix flash units (at least some of them) use a pair of AAA cells instead of the single AA, so some modifications had to have been made. Later revisions of the MAX flash have gone to surface-mount components, though I don't think the circuit has changed much (my sample is a couple of years old). I haven't yet seen any of these new circuits up close and personal.

Kodak MAX Flash Operation:

Refer to Figs. 2 and 3 as you read the following section. Momentarily pressing the CHARGE button (S1) enables base drive to the inverter transistor (Q1, 2SD965) via the emitter follower, Q2. The inverter boosts the battery voltage to in excess of 300 V. The output of T1 is rectified by D1 (unmarked but presumably similar to a 1N4007) and charges the energy-storage capacitor, (C2, 160-µF, 330 V).

Inverter frequency starts at about 5 kHz with C2 completely discharged, and increases to about 11 kHz just before cutoff. The trigger capacitor, C3, charges through R2. The neon bulb, IL1, signals ready when the voltage on C2 exceeds about 275 V_{DC}. In addition, the current flowing through IL1 results in a voltage drop across R3, exceeds the rating of the zener diode (110 V), D2, and then transistor Q3 disables base drive to Q1, and the inverter shuts off—around 300 V_{DC} .

The MPS2111 (Q3) is a PNP transistor, which has an internal-resistor network in its base-emitter circuit. These devices are sometimes called "digital transistors" since they can be used as simple buffers or inverters without addi-

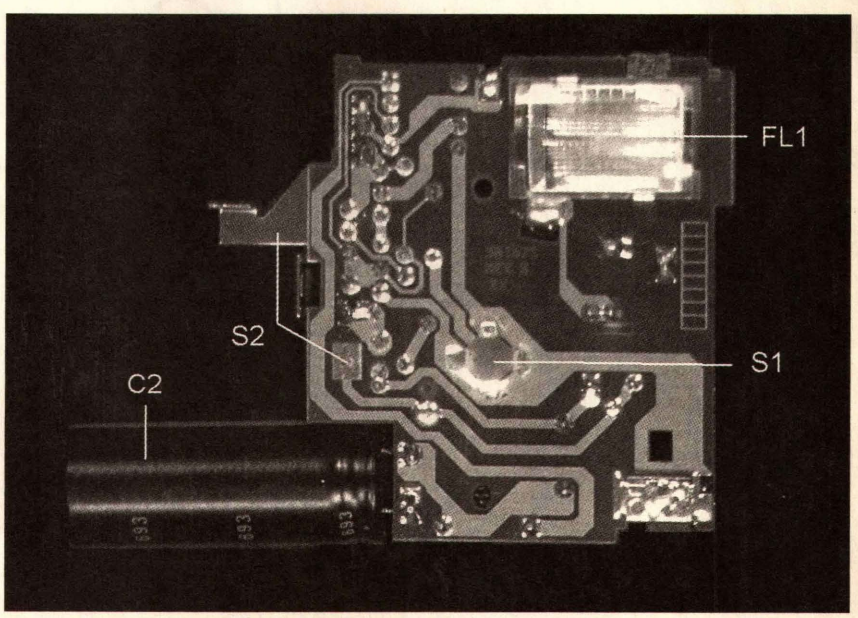

Fig. 3. Here is a photo of the flash circuit that shows the bottom-mounted components.

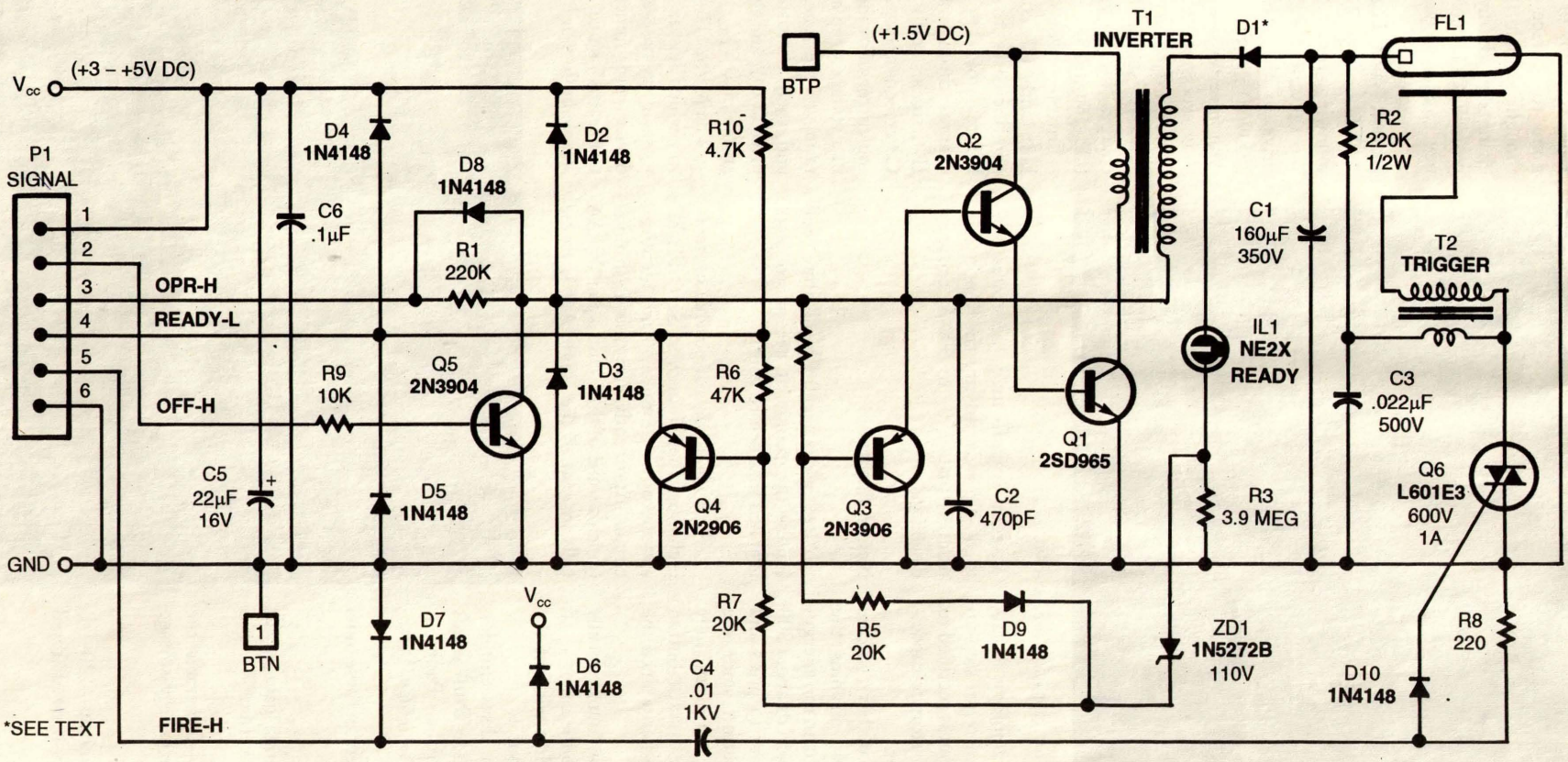

Fig. 4. The circuit changes were designed to take advantage of the way the MAX operated as part of the camera and to minimize rework to its printed circuit board.

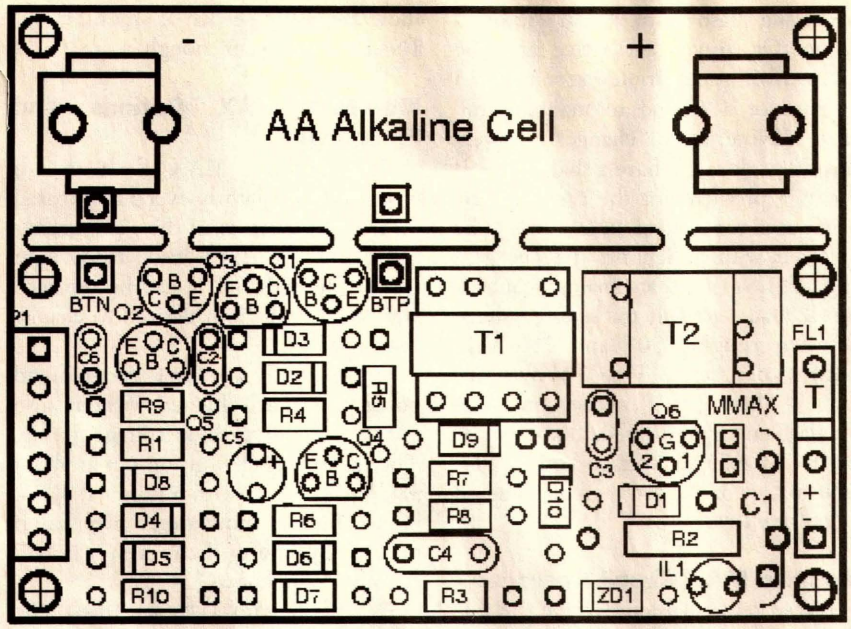

Fig. 5. Here is the PCB Layout shown at 200%.

tional input components. The values of the series and shunt resistors are both 10K for this particular part. However, a common 2N3906 PNP-transistor DOES seem to work in place of this unusual device!

While I am calling IL1 a neon bulb, since it looks like a sort of a runt (shortened) version of the ubiquitous NE2, in order to operate as described above, its on-state voltage drop must be around 190 to 200 V—not the usual 60 V or so one would expect from an NE2. I confirmed this by measuring across one of these bulbs connected to C2 via a 1M resistor.

Pressing the shutter closes S2 (fire), which discharges C3 through T2, generating a high-voltage pulse (4 to 5 kV). This ionizes the xenon gas in the flash-lamp, FL1. The energy-storage capacitor discharges through the flash-lamp. The inverter automatically restarts to recharge C2 after firing.

Kodak MAX Flash Transformer Construction:

T1 consists of a pair of ferrite E-cores, each measuring approximately .4025 × .219 × .187 inches (W × H × D). The center leg and outer legs are each .096 × .187 inches and .06 × .187 inches, respectively. There are no core gaps. The plastic bobbin fits over the center leg and has 1750 turns (give or take a few) of #45 AWG wire for the HV secondary. (Apparently, you can buy wire down (up?) to size #60—less than 0.000350 inches in diameter! Check out MWS Wire Industries *(www.mwswire.com)* if you are really curious about fine wire—(#45 is nothing to write home about!) This is wound first as one clump, distributed back and forth to create a fairly uniform layer without lumps.

There were no separators, as are often found in high-frequency transformers, to divide high-mileage windings. After a layer of plastic tape, the pFrimary consists of 6 turns of #25 AWG wire. A final layer of tape and there you have it! The entire inverter transformer fits in a cube less than 0.5 inches on a side.

Since there is no core gap, this inverter does NOT operate in flyback mode, but rather as a simple-blocking oscillator with a step-up transformer. Therefore, I would predict the maximum voltage (if the limiting circuit were disabled) to be determined, in an ideal world, roughly by the turns ratio of T1 times the battery voltage (minus Q1's saturation voltage), or 1750/6 × (1.5 - 0.3)—about 350 V for a fresh AA cell. This was confirmed on another unit by measuring the amplitude of the primary and secondary waveforms on T1 while operating with D1 removed.

T2 consists of a linear ferrite core, about .065 inches square by .265 inches long, and a plastic bobbin with 12 turns of #33 AWG wire, insulating tape, and about 450 turns of #45 AWG wire on top of this, followed by more tape. The entire trigger transformer is about 0.210 × 0.210 × 0.275 inches.

Transformers like T1 and T2 could be built at home if you have a coil-winding machine. Otherwise, I would expect it to be quite frustrating, since the #45 AWG or finer wire is so thin and fragile. The tensile strength of #45 wire is already significantly less than that of a human hair. Why bother, since they can be salvaged easily enough. However, this information should help, if modifications are desired, as discussed below.

Kodak MAX Flash Notes

Minor component differences may be found in samples of this unit. For example, Q1 may be a 2SD879 or 2SD1146 instead of the 2SD965 shown.

Some versions of this flash apparently have a 120-µF instead of 160-µF capacitor for C2. I wonder if the film speed and/or lens aperture are different in these cameras, since the flash energy is only about ²/₃ as much as with the 160-µF capacitor.

WARNING: Extra precautions must be taken when experimenting with these circuits since they automatically recharge without pressing any buttons! Take care!

Digital Control Of The MAX Flash

Additional circuitry has been added to permit digital (e.g., TTL, CMOS, PIC, etc.) control of the Kodak MAX flash unit. This allows these dirt cheap or free flash units to be used for all sorts of other applications.

While it may be possible to construct the additional circuitry on the original MAX circuit board (there is quite a bit of free space), for my prototype I added a mezzanine board held in place with an insulating-treaded spacer.

Even so, I ended up adding a few parts (like the triac and its drive components) to the back of the PCB. The battery clips were also removed and an external battery holder was added. However, for testing, I used the power 1.5-volt alkaline cell eliminator described below. The total cost of the modifications is about $2 (most of this being for the triac).

Note that for the simplified case of just triggering the MAX or similar flash unit electronically, the triac and associat-

ed components would easily fit on the existing circuit board.

Modified MAX I/O Specifications

Here are descriptions of the control and status signals:

OPR-H—This logic signal controls the inverter.

RUN (TTL High, 2- to 5-V)—Inverter starts and runs but may be overridden by the OFF signal or built-in 300-V limiter.

CRUISE (Open, Hi-Z or Tri-Stated)—No Change. Inverter will continue running or remain off as determined by previous state. Note: The unit will also automatically recharge if fired with OPR open or tri-stated and switching from OFF to CRUISE seems to start up the inverter a high-value resistor to ground may inhibit this "feature.")

STOP (TTL Low, 0 to .4 V)—Inverter stops. Note: Low must be .4 V or less while sinking 15 mA to guarantee off. Use OFF-H to force shutdown if your driving logic can't handle this.

OFF-H—This logic signal disables the inverter regardless of state of OPR.

FIRE-P—This pulse signal will trigger the flash on either edge with a sufficiently powerful driver (assuming the energy storage capacitor is charged). The driving output must be able to sink or source at least 15 mA to guarantee reliable firing (depending on whether you want a negative or positive, or either edge trigger). In order to prevent possible damage to the triac, Q6, it is important that this line be driven hard to assure that Q6 is never turned only partially on. A diode (D10) can be added in series with the gate of appropriate direction to select which edge is used for triggering. For testing, I just substituted a jumper for D10.

READY-L—This output can be used as either a digital indication of full charge or an analog monitor of the energy storage capacitor (C1) voltage in the approximate range of 305 to 310 V_{DC}. As a digital-status signal, READY goes low when the voltage on C1 reaches about 310 V. READY will remain active for a couple of seconds after the inverter cuts out. Therefore, to assure full charge, the inverter should be turned on prior to triggering flash until READY becomes active. Or, leave OPR active and the inverter will run every few seconds for a fraction of a second to maintain full charge. Note: READY changes relatively slowly—it does not have a sharp edge. If this is a problem for the type of logic being used for control, READY should be buffered with a Schmitt Trigger gate (e.g., 74LS14). As an analog feedback signal, READY actually tracks C1's voltage between roughly 305 and 310 V_{DC} (READY goes from 5 V to 0 V over this range). Therefore, if precise control of the flash energy is desired, READY can be fed to an A/D or voltage comparator. The voltage on C1 can then be trimmed by pulsing OPR.

Modified MAX Circuit Operation

Please refer to Figure 4 for the following discussion. The circuit changes were designed to take advantage of the way the MAX operated as part of the camera and to minimize rework to its printed circuit board. Where a new board is to be fabricated, the latter is not an issue; but it turned out that this approach was still more or less optimal.

Operation of the OPR signal for RUN and CRUISE is analogous to the original charge pushbutton of the MAX camera: A TTL high is the same as pressing the button while OPEN is like releasing the button. The addition of a diode D8 allows a solid TTL low or ground to draw enough current out of the drive circuit to kill inverter oscillation. The OFF signal drives the base of Q5, which similarly shorts out the drive to stop oscillation.

The FIRE signal is capacitively coupled to the gate of the triac, Q6, to discharge the trigger capacitor, C3. This is exactly analogous to the way the original shutter contacts worked. An additional circuit, very similar to that of the 300-V limiter, was added for the READY status signal. Its input is derived from the energy-storage capacitor through the same high-voltage neon bulb (IL1) and zener (ZD2), so it turns on at around 300 V. It was found necessary to add a sneak path prevention diode, D9, to block voltage making its way in from the TTL supply and restarting the inverter even if OPR was open.

Clamp diodes have been included on all signal lines. This is sort of insurance to prevent any glitch pulses generated at the time the flash is triggered from feeding back to the logic. I do not know if these are really needed at any time, but 1N4148s are cheap enough!

Modified MAX Options and Precautions

The original MAX flash design charges C1 to slightly over 310 V based on the combination of the 110 V zener (ZD1) and the 200 V neon ready light (IL1). The light (IL1) can be replaced with a zener diode if desired to change this value.

However, I wouldn't recommend going too much higher without also using a C1 of greater voltage rating. The inverter itself will top out at about 350 V_{DC} on C1 (with a nominal 1.5-V input), but its transformer may fail if pushed by more than even a small amount. Who knows?

As noted, with OPR set HIGH, the inverter will run as needed to maintain full charge. This means a few tenths of a second burst every few seconds. If R3, the load resistor for the READY light (IL1), were removed, the charge would decay even slower. I am not sure of the implications for regulation without IL1—the neon bulb would actually go off and on, which may represent substantial hysteresis. However, this scheme should definitely work if IL1 were replaced with a 200-V zener.

Modified MAX Test Circuit

To test the modified MAX, I made up a simple set of switches and used a hex inverter (7404) for input buffers and to drive a the READY LED.

OPR-H: SPDT center off toggle switch selecting +5 (RUN), open (CRUISE), or
Gnd (STOP).

OFF-H: Pushbutton to Gnd (with pullup) buffered by inverter.

FIRE-P: Pushbutton to Gnd (with pullup) buffered by inverter.

READY-L: Two inverters in series drive LED through 220 ohm resistor to +5.

For a more 'high-tech' approach, use a PIC or the parallel port of your PC.

Modified MAX PCB Layout

A printed circuit-board layout is also available. The entire double-sided circuit board is 2.2 × 1.6 inches. Power can be provided by the built-in AA-size

battery holder (which may be removed by snapping along the score lines) or via an external 1.5-volt power supply.

A complete PCB artwork package may be downloaded in standard (full resolution 1:1) Gerber PCB format (zipped) from *www.repairfaq.org/sam/mmaxgrb.zip*

The Gerber files include the solder-side copper, solder mask, top silkscreen, component-side copper, and drill-control artwork. The original printed-circuit board CAD files and netlist (in Tango PCB format) are provided so that the circuit layout can be modified or imported to another system if desired. Note: I don't guarantee that the parts values in the Tango PCB file are accurate—go by the schematic. The text file mmax.doc (in mmaxgrb.zip) describes the file contents in more detail.

Up to 350 V_{DC} Inverter from 1.5-V Alkaline Cell:

Using the basic circuit of the electronic flash unit from a disposable-pocket camera, it is possible to generate any voltage, from a few V to 350 V or more, from a 1.5-volt AA alkaline battery. Similar modifications could be made to other pocket camera or external flash unit circuits. Refer to Fig. 6.

By rewinding the inverter transformer, any output voltage up to about 350 V_{DC} can be obtained from a 1.5-volt alkaline cell. More than 350 V is probably possible, but just thinking about winding the needed secondary makes me tired!

The original circuit board can be used and is very convenient, though a more compact unit can be constructed if you use a bit of perf board or your own PCB. Note that for higher voltages, Q2 in the original MAX schematic may be needed. For low-voltage operation, performance is much better without it. I don't know what the break-even point is, so you may want to leave a spot for Q2 just in case.

The main difficulty is in disassembling T1 in a nondestructive way. It seems that the ferrite core is held together by an adhesive which is very tough and resistant to any solvent that won't destroy the plastic bobbin and wire insulation as well. Therefore, you may need to sacrifice two of these—one so that just the ferrite core can be salvaged by soaking the transformer in some nasty solvent (maybe lacquer thinner will work) to dissolve the adhesive.

For the 6-turn primary, the number of turns required on the secondary is approximately:

$$N = 6 * (V_{OUT} + 1.2) / 1.2$$

assuming a small load on the output. So, for 4 V_{DC}, N = 26; for 50 V_{DC}, and for N = 256 300 V_{DC}, N = 1506. The original circuit topped out at about 350 V_{DC} with N = 1750.

It may be possible to use multiple-output windings to provide more than one output voltage, but as will be shown below, all output power must be drawn on the forward stroke of the converter since the flyback pulse of the reverse stroke is needed to drive the voltage on C1 and the base of Q1 negative.

I have done the modifications for the 4-V_{DC} version by removing the original 1750-turn secondary (I had to do this anyway so I could confirm the number of turns for the circuit description) and replacing it with a 26-turn winding of #32 wire. Unfortunately, I also had to Epoxy the half-dozen pieces of the ferrite core back together after a somewhat-destructive disassembly, but I don't think there are any significant gaps left in the core (I confirmed that the transformer still worked by installing another set of undamaged original windings and checking that it still charged and fired the flash properly).

With no load, the output reaches about 5 V in a fraction of a second. With a 100-ohm load, the output drops to a bit over 4 V.

More information, including a discussion on using this circuit as a simple way of obtaining a dual op-amp supply from a single alkaline cell (dual part as yet to be tested) can be found under "Various Schematics and Diagrams" at *www.repairfaq.org/sam/samschem.htm.*

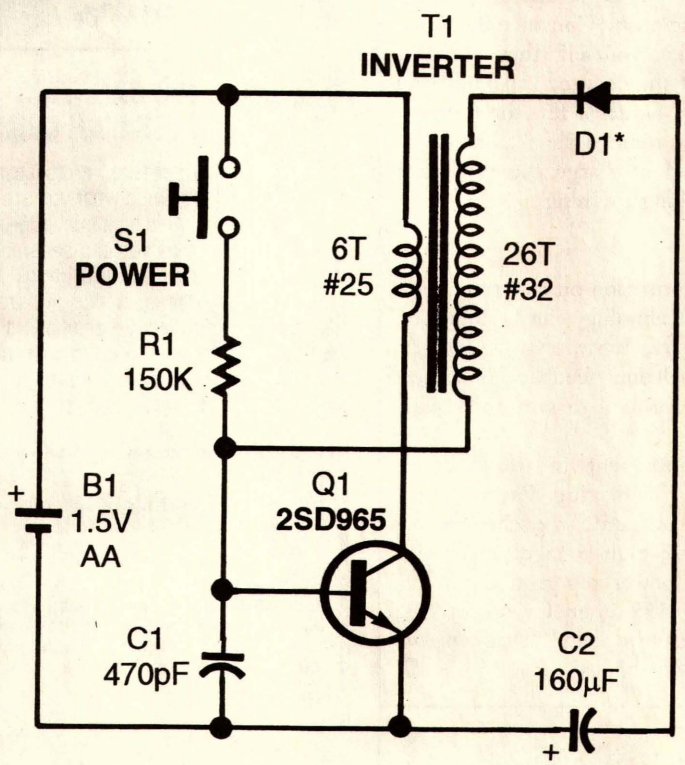

Fig. 6. By rewinding the inverter transformer, any output voltage up to about 350 V_{DC} can be obtained from a 1.5-volt alkaline cell.

1.5 V Alkaline Cell Eliminator

I constructed this cell eliminator to provide a means of testing and experimenting with electronic-flash circuits (and modifications to these circuits) that run on single alkaline cells as their appetite for these is quite huge. Refer to Figure 7.

The power transformer (T1) that I used was actually rewound from one that was rated at 12 V, 1 A. This was a high-quality transformer, so removing two-thirds of the secondary was quite a pain. Actually, the purpose was an experiment to see if it could be done non-destructively. Conclusion: Just barely. Obviously, a transformer actually designed to produce about 4 or 5 V at 3

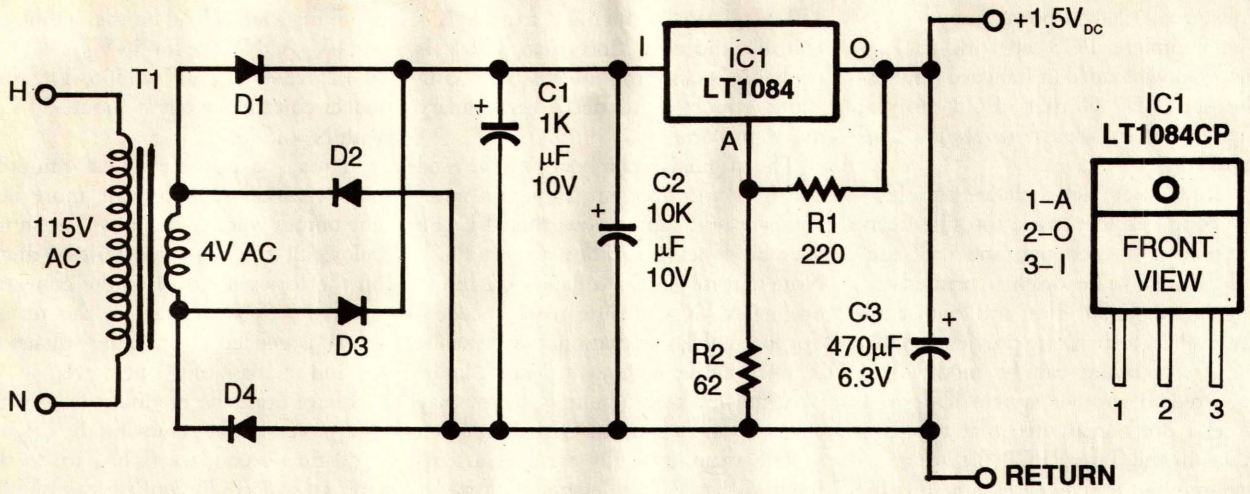

Fig. 7. The regulator (IC1) is an LT1084CP, which is similar to an LM317 but is a low-dropout type rated at 5 A max.

A could also be used. Diodes D1 to D4 can be individual diodes or a bridge rated for at least 3 A.

The regulator (IC1) is an LT1084CP, which is similar to an LM317 but is a low-dropout type rated at 5 A max. I had a pile of these left over from a certain multi-million dollar project that had been cancelled due to upper management foot in derriere disease. An external-pass transistor may be needed to use an LM317 because of the peak current requirement.

Despite the transformer only being rated for 1 A, with IC1 on a modest heatsink, the supply seems perfectly happy putting out 3 A at 1.5 V for an extended period. I don't know that I would run it all day at this high current but for my purposes, it seems fine.

It turns out that the typical electronic flash circuit from a disposable camera (like the Kodak MAX) draws more than 3 A at the start of its recharge cycle. So, the voltage does dip a bit, but this doesn't affect much of anything. Recharge time with the power supply is at least as rapid as with a fresh alkaline cell. The voltage from an alkaline cell also dips a bit under these conditions.

Obviously, this circuit could be easily modified to put out 2.4 V_{DC} (for a pair of NiCd cells), 3 V_{DC} (for two alkalines), or whatever else you might need.

Obtaining Kodak MAX or Other Flash Units

I've seen these or similar flashes from normal 35-mm cameras for $1–$3 listed by various surplus places, but there is probably no need to pay even that much. If you are friendly with your local camera store or developing kiosk, go ask there. While some actually send the camera carcasses back to the manufacturer for recycling after removing the film, many do not. Sometimes only certain models will be returned—the rest end up in the trash. Convince them that you won't kill yourself (they probably heard about the charged caps) and you may be able to get a few for nothing. However, do remove the alkaline cells , and test and discharge the capacitors before touching anything!

Wrapup

More information on electronic flash and strobe technology can be found on my Web site, *www.repairfaq.org*. As always, I welcome feedback of almost any type via e-mail to sam-gp@repairfaq.org.

Please note that in the "Service Clinic" on "Salvaging Parts, High-Voltage Circuits, etc.," the schematic for the adjustable high-voltage power supply omitted power and ground connections for the 555 timer ICs. A corrected schematic may be found at *www.repairfaq.org/sam/hvgen32.pdf*. P

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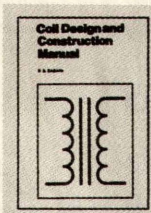

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CHARLES D. RAKES

The 339 Quad Comparator IC

NOTE:
The parts lists in the December 2002 issue had incorrect capacitor values. All "mF" should have read "µF".

This month we're going to look at some circuits designed around the LM 339 quad-comparator IC. The LM 339 is basically designed to compare two input voltages and produce an output. We'll look at how that's done, and go beyond that to see what other jobs they can do, as well. Some of the circuits I'll share will be taken from my on-going electronic target project. However, before we jump into the circuitry, let's take a look at the basic functions of the LM 339.

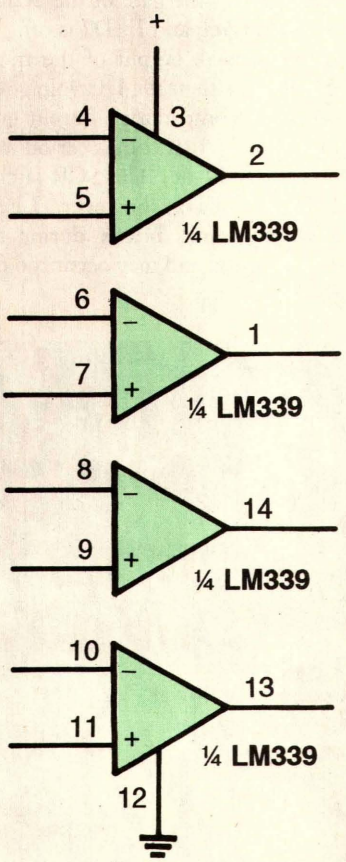

Fig. 1. There are four independent voltage comparators in the 14-pin package. The LM 339's pin out is shown above. Note that pin 3 is positive and pin 12 is ground.

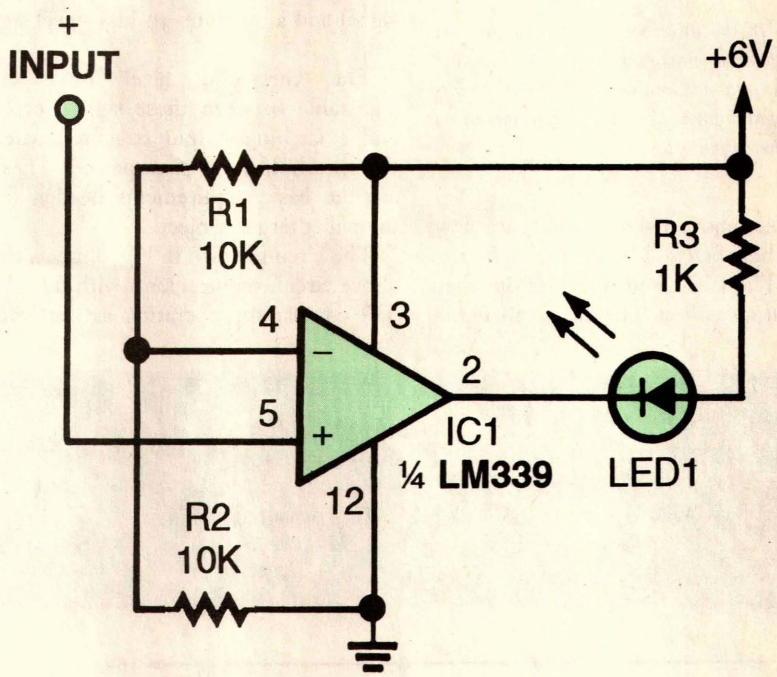

Fig. 2. In this non-inverting comparator-circuit configuration, when the input voltage at pin 5 is above 3 volts the output is high, and when below 3 volts the output is low. The LED is turned on when the output is low.

An Inside Look

There are four independent voltage comparators in the 14-pin package. They are designed to operate from a single- or dual-voltage source, with a voltage range of 2 to 32 volts. The quiescent current drain is very low (typically below 1-mill) and independent of supply voltage. The input voltage can be as great as the supply voltage. The output is an open NPN collector and can sustain a short circuit to ground without damage. The LM 339's pin out is shown in Fig. 1. Note that pin 3 is positive and pin 12 is ground. The non-inverting comparator-circuit configuration is shown in Fig. 2. When the input voltage at pin 5 is above 3 volts the output is high, and when below 3 volts the output is low. The LED is turned on when the output is low. The inverting circuit configuration is shown in Fig. 3. When the input

PARTS LIST FOR INVERTING COMPARATOR (FIG. 2)

SEMICONDUCTORS
LED–LED, any color
IC–LM 339 Quad comparator IC

RESISTORS
(All resistors are ¼-watt, 5%, unless otherwise noted)
R1, R2–10,000-ohm
R3–1000-ohm

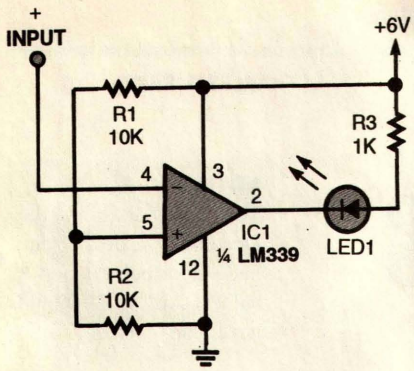

Fig. 3. In the inverting circuit configuration shown here, when the input at pin 4 is above 3 volts the output is low, and when below 3 volts the output is high. The LED is also turned on when the output is low.

at pin 4 is above 3 volts the output is low, and when below 3 volts the output is high. The LED is also turned on when the output is low. The circuit in Fig. 4 modifies the comparator's output to reverse the LED on/off function. This easy change can be beneficial when using the output as an indicator.

Picking Up The Vibes

I have a vibration-sensing transducer that produces an AC signal-output level of up to 600 millivolts peak-to-peak, while the circuit's actual working range is only between10 to 200 millivolts. One important requirement is to be able to distinguish between a low-level output signal and a medium- to high-level signal.

The threshold level must be adjustable between these signal levels, and a latching output triggered when the threshold level is surpassed. These are the basic requirements needed for my pellet target project.

The circuit shown in Fig. 5 meets the above circuit requirements with the LM 339 comparator operating as the level

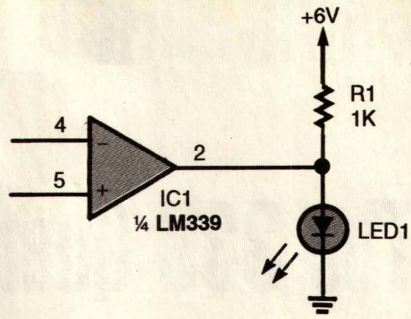

Fig. 4. This circuit modifies the comparator's output to reverse the LED on/off function. This easy change can be beneficial when using the output as an indicator.

detector and output driver. The 5-k potentiometer (R6) sets the input sensitivity from 0 to near 600 millivolts. Diode D1 protects the comparator's input from a negative input pulse greater than .6-volts. The comparator is connected in a non-inverting configuration with the output normally low with no input signal at pin 5. LED1 is glowing, and the input to the gate of the SCR is near ground level; and LED2 is off.

When the peak output of the transducer is greater than the DC voltage set with R6, the comparator's output goes positive during that time period and triggers the SCR on. The SCR latches on lighting LED2; however, LED1 actually only blinks briefly during the same time period and may occur too fast to observe.

PARTS LIST FOR NON-INVERTING COMPARATOR (FIG. 3)

SEMICONDUCTORS
LED–LED, any color
IC–LM 339 Quad comparator IC

RESISTORS
(All resistors are ¼-watt, 5%, unless otherwise noted)
R1, R2–10,000-ohm
R3–1000-ohm

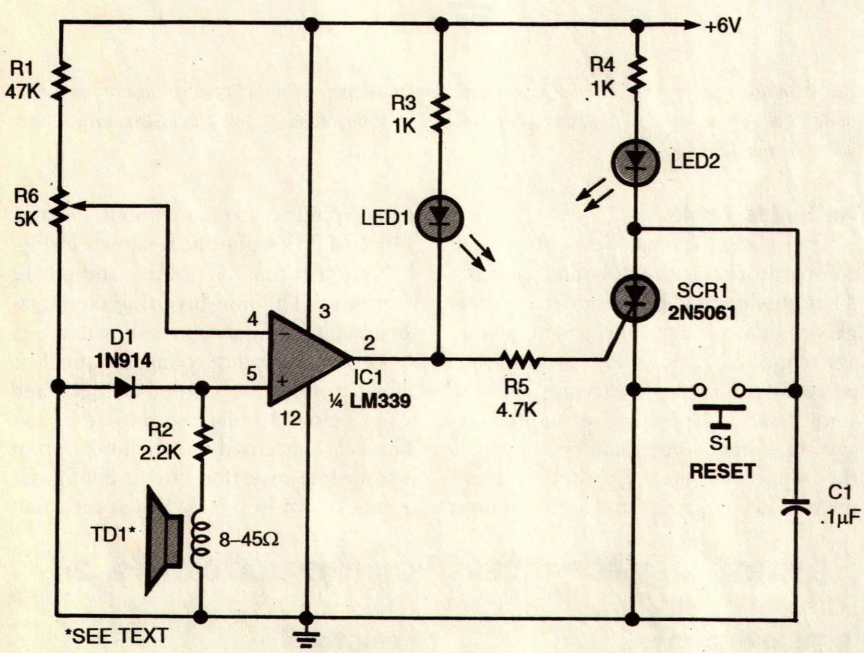

Fig. 5. Looking at this comparator circuit we see that the 5-k potentiometer (R6) sets the input sensitivity from 0 to near 600 millivolts. Diode D1 protects the comparator's input from a negative input pulse greater than .6-volts.

PARTS LIST FOR "PICKING UP THE VIBES" (FIG. 5)

SEMICONDUCTORS
D1–1N914 silicon diode
IC–LM 339 Quad comparator IC
LED1, LED2–LED, any color
SCR- 1–2N5061 or similar 0.8-amp SCR.

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1, R3, R4–1000-ohm
R2–2200-ohm
R5–4700-ohms
R6–5K pot.

ADDITIONAL PARTS AND MATERIALS
TD-1–8-32-ohm speaker/transducer
C1–.1-µF, ceramic-disc capacitor
S1–Normally open push-button switch

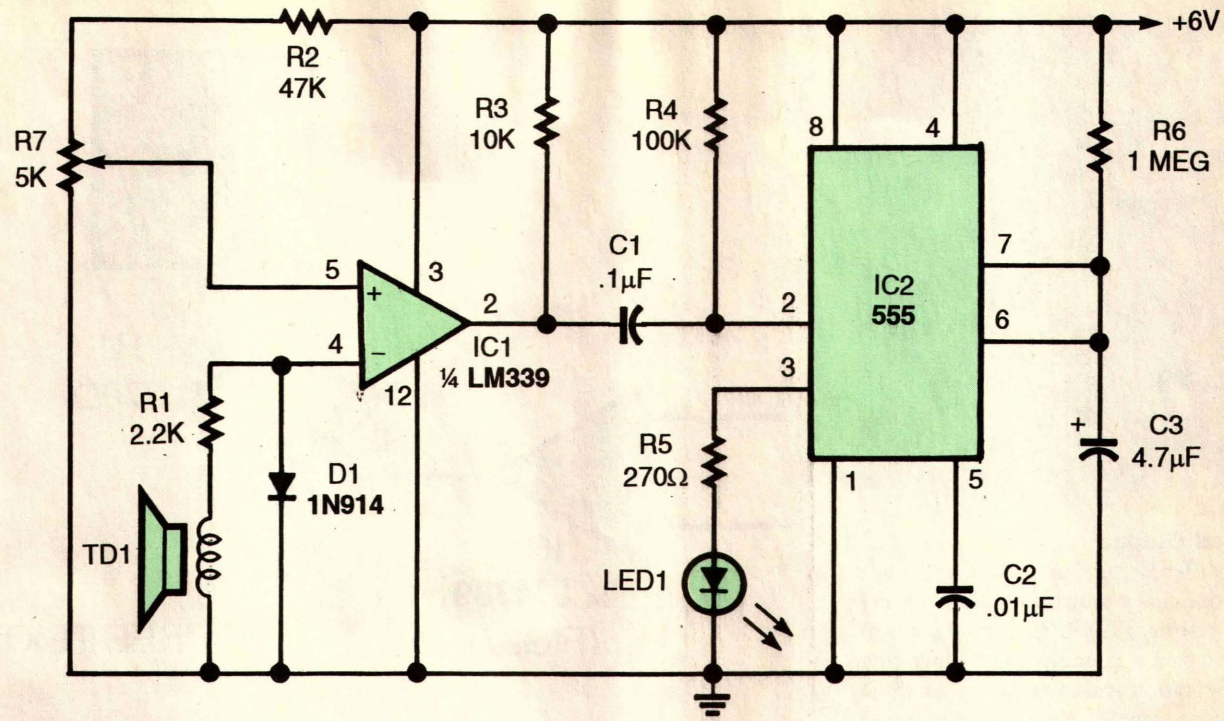

Fig. 6. This circuit offers a timed-on indicator using a super-bright LED. The comparator in this version is connected in an inverting configuration with a high output when no input signal is present.

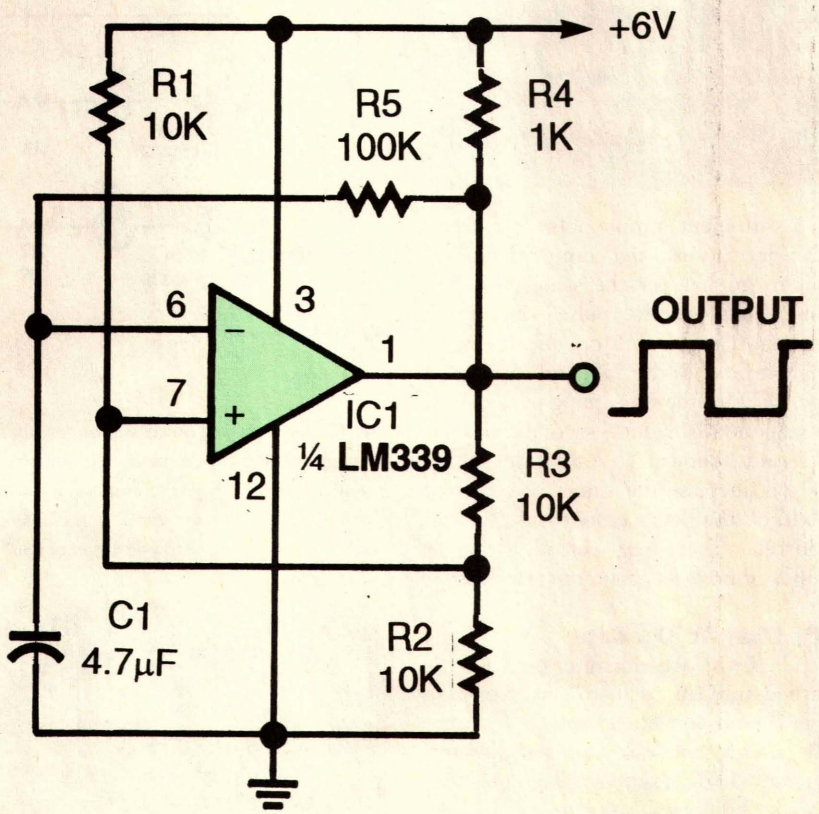

Fig. 7. The LM 339 comparator can easily be turned into an oscillator, as shown here. Components R5 and C1 form the RC timing network that sets the frequency.

PARTS LIST FOR TIMED OUTPUT (FIG. 6)

SEMICONDUCTORS

D1–1N914 Silicon diode
LED1–LED, any color
IC-1–LM 339 Quad comparator IC
IC-2–555 timer IC

CAPACITORS

C1–.1-µF, ceramic-disc
C2–.0-1µF, ceramic-disc
C3–4.7-µF, 25-WVDC, electrolytic

RESISTORS

(All resistors are 1/4-watt, 5% units.)
R1–2200-ohm
R2–47,000-ohm
R3–10,000-ohm
R4–100,000-ohm
R5–270-ohm
R6–1-megohm
R7–5K pot.

ADDITIONAL PARTS AND MATERIALS

TD-1–8-32-ohm speaker/transducer

PARTS LIST FOR "IT'S OK TO OSCILLATE" (FIG. 7)

SEMICONDUCTORS
IC–LM 339 Comparator

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1,R2,R3–10,000-ohm
R4–1000-ohm
R5–100,000-ohm

CAPACITORS
C1–4.7-µF, 24-WV_{DC}, electrolytic capacitor

Timed Output

A different version of the circuit, see Fig. 6, offers a timed-on indicator using a super-bright LED. The comparator in this version is connected in an inverting configuration with a high output when no input signal is present. A 555-timer IC is connected in a one-shot multivibrator with the on-time set by the RC values of C3 and R6. Pin 2 of the 555 is the trigger input, which requires a negative pulse to start the one-shot multivibrator. The 555's output at pin 3 supplies the current to light the super bright LED.

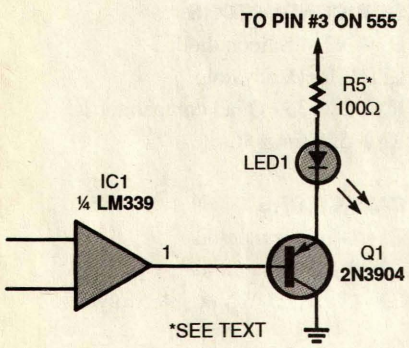

Fig. 9. Simply by adding a PNP 2N3904, or a similar transistor, to the output of the LM 339, the LED's current can be adjusted up to 50 milliamps for full light output.

PARTS LIST FOR "KICK UP THE POWER" (FIG. 9)

Q1–2N3904 PNP transistor, or similar type
LED–Super-Bright, see parts list for Fig. 8.

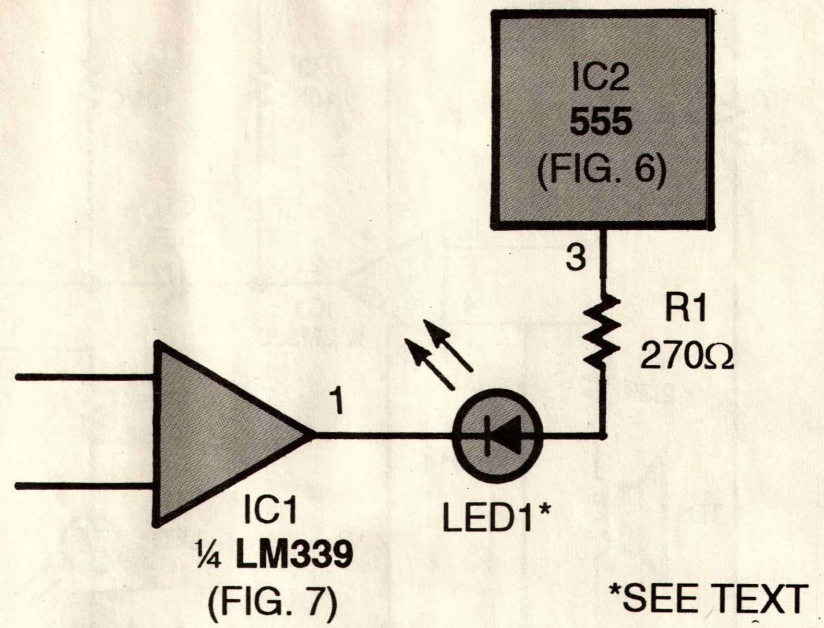

Fig. 8. A 555's output supplies the positive voltage for the LED during its timing cycle, and the oscillating LM 339 supplies the ground return for the LED's cathode.

PARTS LIST FOR THE SUPER BRIGHT LED (FIG. 8)

LED–Radio Shack super-bright LED, part # 276-086A.
R1–270-ohm, ½-watt, 5% resistor

A sufficient input pulse from the transducer causes the comparator's output to go low for the same period of time. This negative pulse triggers the one-shot multivibrator, producing a high at pin 3 of the 555, and turning on the LED for the RC timing period. The time period is about 5 seconds with the RC values shown. To extend the timing period, increase the values of either or both of the RC components; and to shorten the timing period, decrease either or both RC component values.

It's Okay To Oscillate

The LM 339 comparator can easily be turned into an oscillator, as shown in Fig. 7. Components R5 and C1 form the RC timing network that sets the frequency. The circuit oscillates at about 1.5 Hz. Lowering the value of either one or both RC components can increase the frequency. Going the opposite direction will lower the oscillator's frequency.

A flashing light is much more atten-

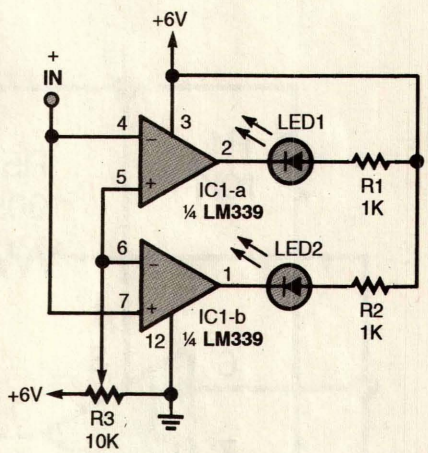

Fig. 10. The inputs of two comparators can be cross connected, as shown in this circuit, to produce dual and opposite outputs. By using this arrangement both a timed and a latched output can be produced in one target circuit.

PARTS LIST FOR "DOUBLE CROSS" (FIG. 10)

SEMICONDUCTORS
IC–LM 339 Quad comparator
LED1, LED2–LED, any color

RESISTORS
R1,R2–1000-ohm (¼-watt, 5%)
R3–10K pot.

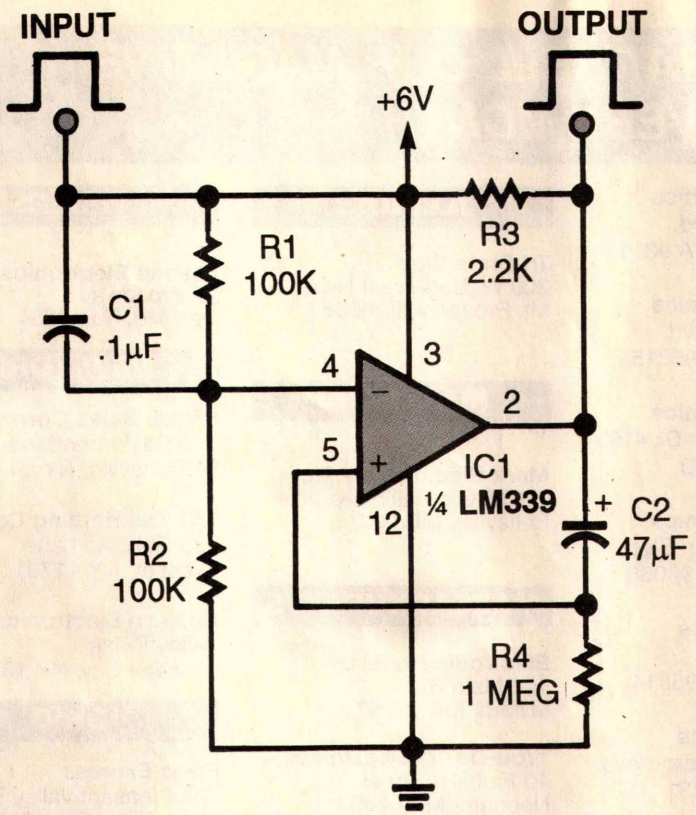

Fig. 11. This LM 339 circuit turns one of the comparators into a one-shot multivibrator. A positive pulse at the negative input of the comparator causes the output to go high and allows C1 to charge through R4.

tion-getting than a steady one, and that is exactly what happens when the circuits in Figs. 6 and 7 are combined as shown in Fig. 8. The 555's output supplies the positive voltage for the LED during its timing cycle, and the oscillating LM 339 supplies the ground return for the LED's cathode. Resistor R4, in Fig. 7, is removed and the cathode of the LED connects to pin 1 of the 339.

Kick Up The Power

The super-bright LED can operate at a maximum of 50 milliamps. The circuit in Fig. 9 will allow the circuit in Fig. 8 to kick up the power.

Simply by adding a PNP 2N3904, or a similar transistor, to the output of the LM 339, the LED's current can be adjusted up to 50 milliamps for full light output. Resistor R5 sets the maximum current for the LED, and a 100-ohm resistor is a good value to start with.

Double Cross

The inputs of two comparators can be cross connected, as shown in Fig. 10, to produce dual and opposite outputs. Let's get back to the circuits in Figs. 5 and 6. In Fig. 5, the transducer's output is connected to the positive input of the comparator to produce a positive-going output to trigger the SCR. In Fig. 6, the transducer drives the negative input to produce a negative output, triggering the input of the 555 timer. By using this arrangement both a timed and a latched output can be produced in one target circuit.

Our last LM 339 circuit (see Fig. 11) turns one of the comparators into a one-shot multivibrator that can be used to replace the 555 in Fig. 6. A positive pulse at the negative input of the comparator causes the output to go high and allows C1 to charge through R4. The 47-µF capacitor and 1-megohm resistor offer about 15 seconds of timed output.

That's about all I have this visit. Thanks for allowing me to share some of my on-going design work. Hopefully some of these circuits can be of use in one of your projects. Stay tuned, 'cause next month who knows what we'll be getting into. P

PARTS LIST FOR THE ONE SHOT (FIG. 11)

SEMICONDUCTORS
IC–LM 339 Quad comparator

RESISTORS
(All resistors are ¼-watt, 5% units.)
R1, R2–100,000-ohm
R3–2200-ohm
R4–1-megohm

CAPACITORS
C1–.1-µF, ceramic-disc
C2–47-µF, 25-WV_{DC}, electrolytic

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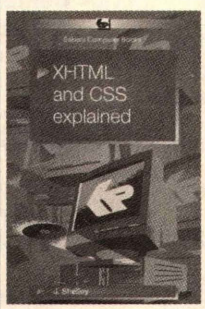

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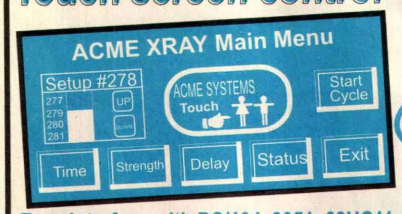

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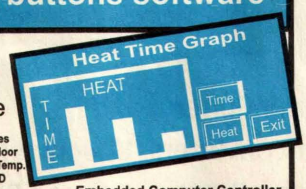

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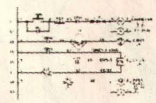

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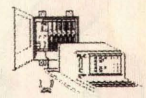

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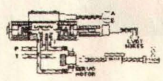

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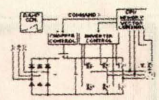

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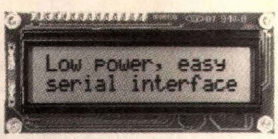
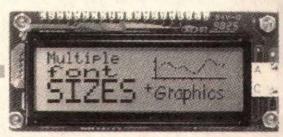


BPI-216N
- 2x16 text LCD
- 2400/9600 bps
- $45 (non-backlit)

SGX-120L
- Mini graphics LCD
- 2400/9600 bps
- just $99



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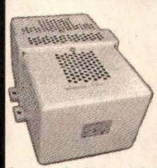

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- Serial EEPROMS
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- D/A and A/D conversion - several methods
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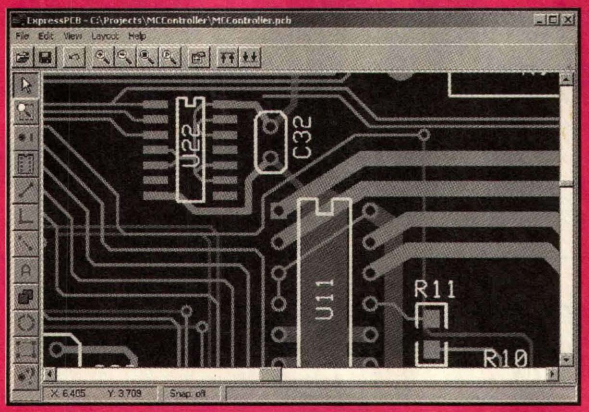

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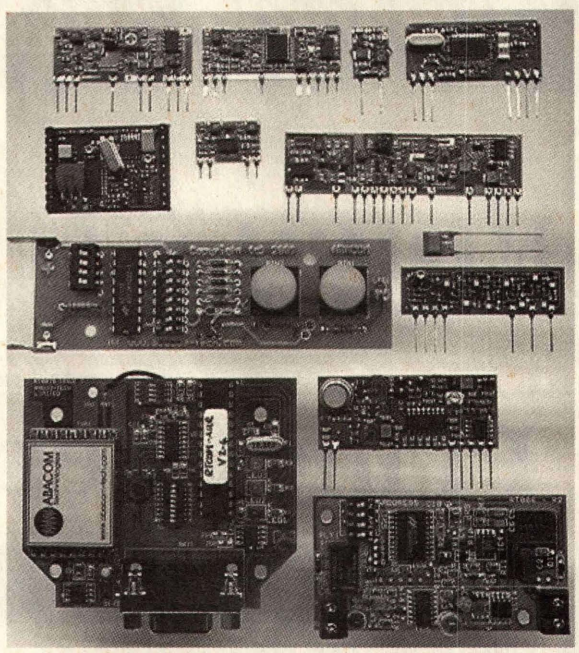

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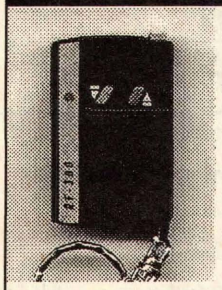

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- 300' (XT), 150' (T) Range
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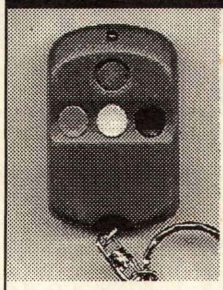
- 12 Volt Battery and Keychain Included
- Current Draw: 4.8 ma
- Fully Assembled in Case
- Dimensions: 1.25" x 2.0" x .5"
- Push both buttons for the 3rd Channel
- Slide Button Cover Included

4 Button / 15 Channel Transmitter



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- 250' Range
- Frequency: 318 MHz
- 6,561 Settable Security Codes
- 12 Volt Battery and Keychain Included
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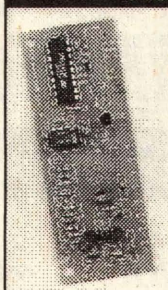
- Fully Assembled in Case
- Dimensions: 1.35" x 2.25" x .5"
- Push combination of buttons to achieve up to 15 channels

2-4 Data / 3-15 Channel Receivers



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RF300RM

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RF304RL
RF304RM

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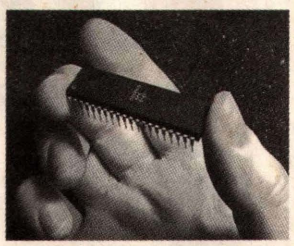
-20mips,faster than pic/8051
-20 pin DIP part #MV1200

oem (1k) **$1.99**

eval (1) **$7.00**



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-8K flash, 512ee, 512nvram
-Watchdog with internal osc.
-40 pin DIP part #MV8515
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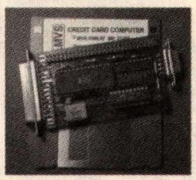
CREDIT CARD COMPUTER



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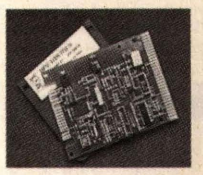
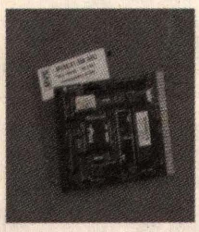
oem (1k) price 14.20 eval kit (1) $50.00

PC WATCHDOG CARD

No More Hangups!



Reboots PC on hardware/software hang
3 versions: RESET, TIMER, PHONE
reset version oem $21.30, eval kit $75



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Program in Turbo C, BASIC, MASM, etc.
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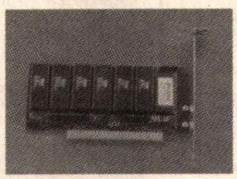
Lowest power lowest cost PC compatible available
XT: oem $27 eval $95 AT: oem $55 eval $195

PC SOLID STATE DISK



Replace mechanical drives with faster, more relaible, more secure solid-state.
Use FLASH, NVRAM, UV EPROM.
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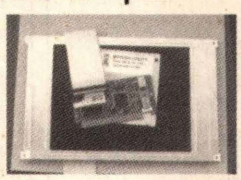
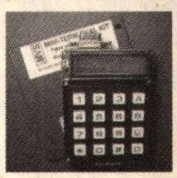
640x480 VGA LCD $27

Controller for most single/dual scan LCDs
Works with lo-res (160x120, 320x240,etc.)
Use with PC or SBC, standard VGA BIOS
Source code demo shows VGA initialization
Adaptable for other CPUs (i.e. Z80, HC11)
oem(1k) $27 evalkit(1) $95 w/10"LCD $195



SERIAL MINI-TERMINAL

RS232 terminal for Stamp, PC, Z80, AVR etc.
-super low-current, powers from serial line
-LED backlit LCD, visible in all conditions
-115.2kbps, DB9 conn, simple commands
-specify 20 customizable or 16 tactile keys
eval(1) $75,oem(1k) $21.30,w/BASIC cpu $27



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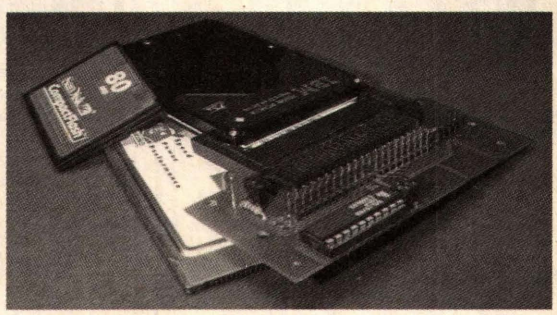
-simple software commands
-baud rates up to 115.2kbps
-$14 IDE & $21 ISA/104 versions

oem(1k) **$27**

eval kit(1) **$95**



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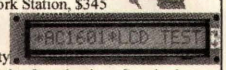
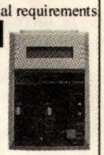
LCD Modules



Over 47 low cost, high quality character/ graphic LCD modules for selection. Standard reflective mode with black/blue dots on yellow green background. Optional black & white retardation film, anti-glare surface with protective layer. Detailed specs in pdf format available on our web site. Contact us for quantity orders or special requirements

IC/ (EP)ROM Programmers



IC testers: Displays 16 characters in one line
Average search time: 0.8 sec
14 ~ 24 pins (**DIC-17001**, Digital $209.95)
8 ~16 pins (**LIC-17002**, Analog $579.95)
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Stand-alone mode, and PC based mode
Operations: type/ check/ read/ verify/ disk/ help/ process
ROM Programmer: UDP-17010, $659.95
Supported Devices: (E)EPROM, PAL, Serial EEPROM GAL, BPROM, PEEL, EPLD, EEPLD, MACH, ROM MAX, ISPLSI, IX 74/54, COMS 40/ 45, DRAM, SRAM
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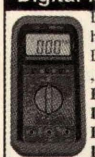
Capacity: 12 pcs;
U-V tube: GL-4;
Tube life: 3000 hrs;
Wavelength: 2537°A

Digital Multimeters



3 1/2 digit LCD, Data Hold, Diode, Continuity, Frequency counter (10 MHz), hFE, Resistance: 10M Ω, DCV/ACV: 1000/750V DCA/ACA: 10A; Test leads & Protective Holster , K type Temp. probes(DMM1250) are included.
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DMM-1230: $54.95, Capacitance test.
DMM-1240: $64.95, Bat. Cap. Logic
DMM-1250: $84.95, Bat. Cap. Temp.

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LCR-03063: $59.95; **LCR-01130**: $134.95;
LCR-01131: $209.95; **DCM-01128**: $114.95;

	(LCR-03063)	(LCR-01130)	(LCR-01131)
Inductance:	2mH~20H	200µH~200H	1mH~10kH
Capacitance:	2nF~200µF	200pF~2000µF	1000pF~10mF
Resistance:	200Ω~20MΩ	20Ω~20MΩ	10Ω~10MΩ

DCM-01128: Capacitance Meter, $114.95, 500 pF ~ 50mF

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Voltage: 0 ~ 200 V
Accuracy: 1 % rdg + 2dgts
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Resistance: 10/ 100/ 1000 Ω, within 3% of full scale
Voltage: 30V AC within 3% of full scale.

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HP-9060: $15.00
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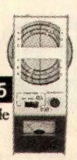
HP-9258: $39.00 (100:1) 250MHz
HP-2100: $20.00,
(10:1) 100Mhz, (1:1) 15MHz
HP-9100: $20.00
(10:1) 10MHz, (1:1) 6MHz
HP-9250: $29.00, (10:1) 250Mhz, (1:1)6MHz
LP-02050: Logic Probe, $22.95, Max Input Freq 50MHz TTL, DTL, CMOS, MOS tests.
LR-02002: Logic Pulser, $26.95,
Max Input Freq: 50MHz, Pulse width: 10µs
LPR-02001: Logic Probe & Pulser, $33.95

Grid Dip Meter: DM-4061, $89.95



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Modulation: 2 KHz sinewave.

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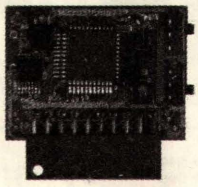

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32K EE+32K RAM (#MS11SP64K)...$90

**** includes MicroStamp11, manual, PC software (free-ware assembler, SBASIC compiler, MicroLoad utility, and sample programs), serial cable, Docking Module, and accessories.***

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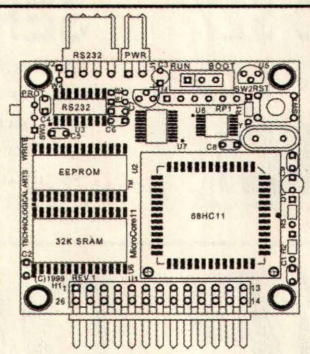
Embed MicroStamp11 modules into your product! only $20 each (100-pc. price, 8K version)

MicroCore-11™



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- 12 inputs/outputs plus 8 analog inputs
- RS232, 5V regulator, 8MHz crystal
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- now available in Turbo version (9.83MHz)

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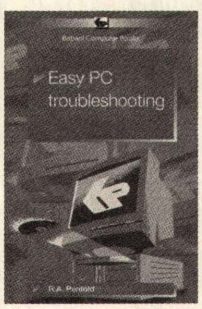

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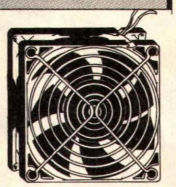

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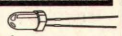

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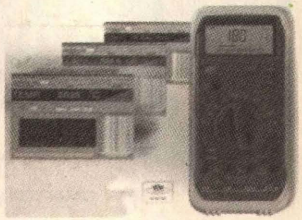

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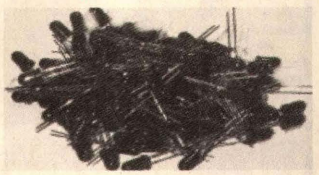

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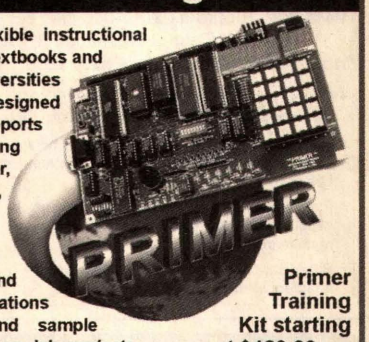

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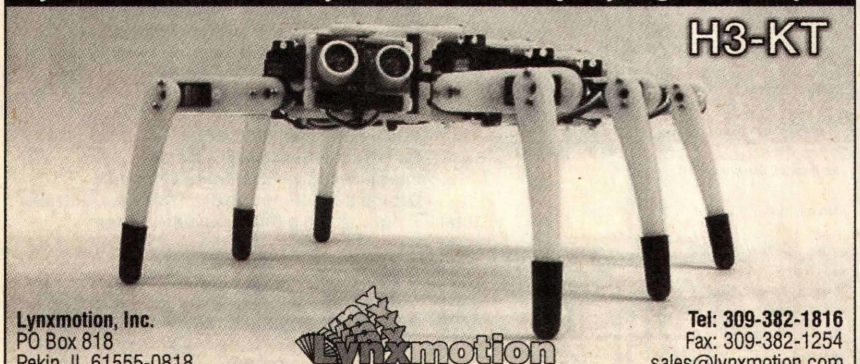

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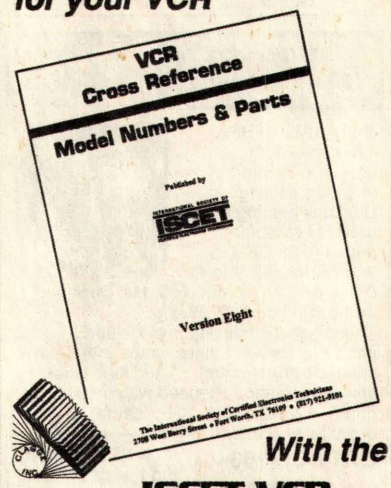

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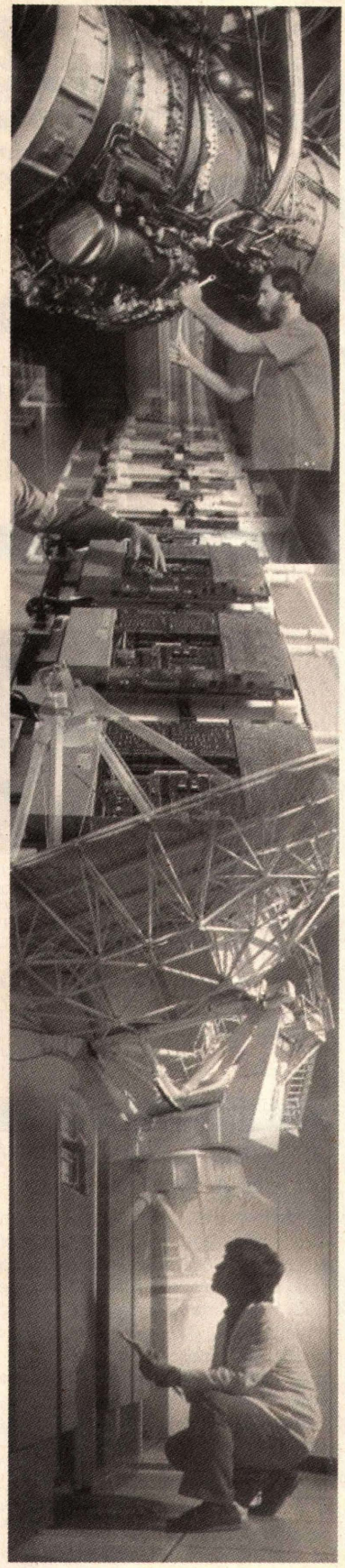

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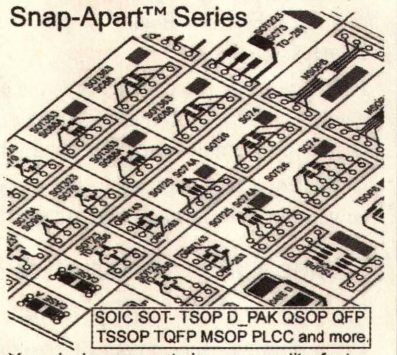

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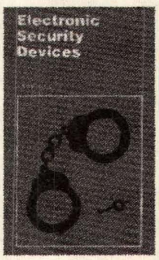

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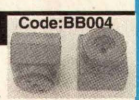

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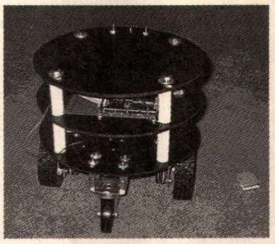

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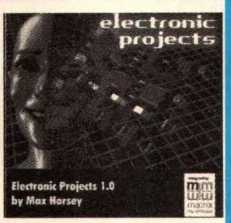

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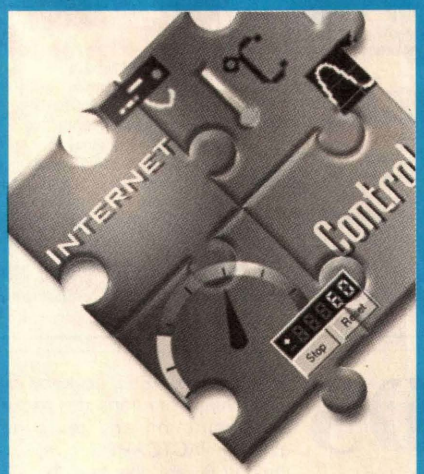

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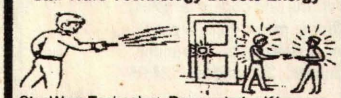

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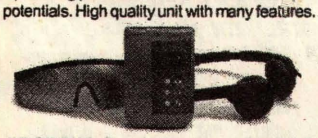

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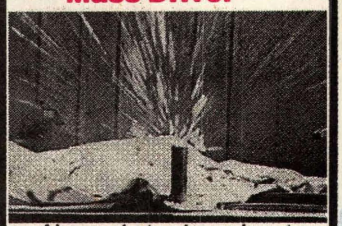

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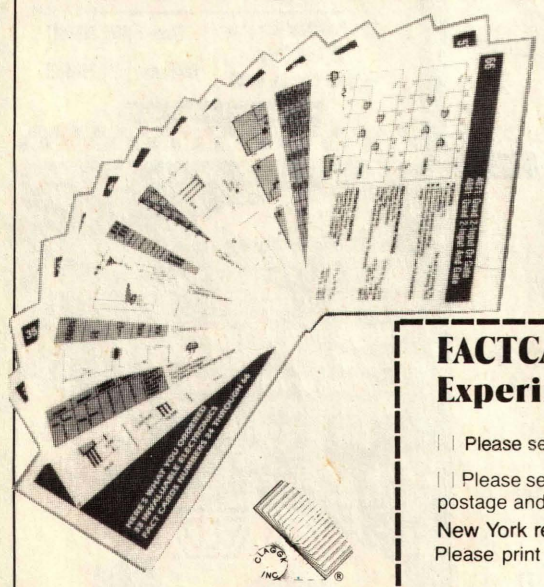

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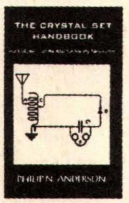

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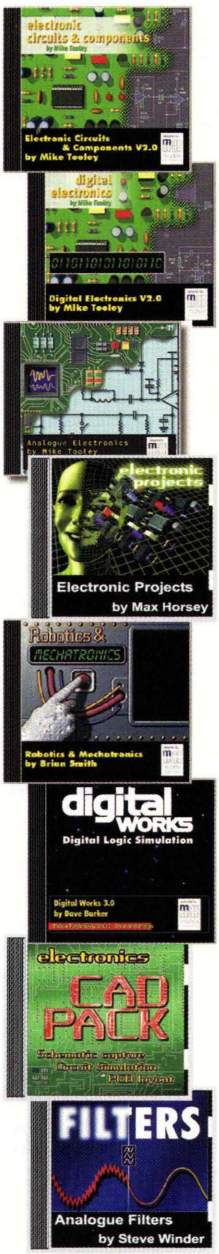
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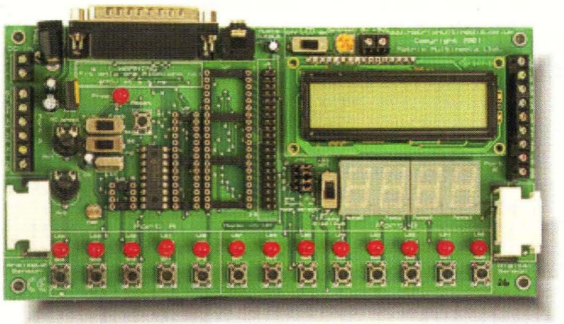
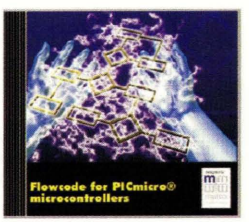
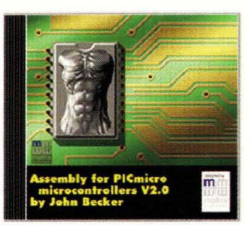


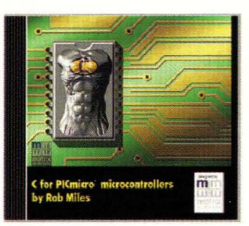
This flexible development board allows you to program 8, 18, 28, 40 pin PICmicro microcontrollers as well as test/develop code. All programming software is included and several resources which allow students to learn and program PICmicro microcontrollers are available - Flowcode, C for PICmicro microcontrollers and Assembly for PICmicro microcontrollers. A board is needed for the CD's below:



Flowcode is a very high level language programming system for PICmicro® microcontrollers based on flowcharts. Flowcode is a powerful language that uses macros to facilitate the control of complex devices like 7-sement displays, motor controllers, and LCD displays. The use of macros allows students to control highly complex electronic devices without getting bogged down in understanding the programming involved. Board not included.



The **Assembly for PICmicro microcontrollers** CD ROM (previously known as PICtutor) contains a complete course in programming the PIC16F84 microcontroller from Arizona Microchip. The CD includes a full suite of tutorials starting at basic concepts and progressing complex techniques including interrupts. An IDE and all programming tools are included. Board not included.



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- ✓ Visible and audible display of your heart rhythm
- ✓ Re-usable sensors included; just like visiting the hospital!
- ✓ Bright LED "beat" indicator
- ✓ Monitor output for oscilloscope display

Enjoy learning about the inner workings of the heart while covering the stage by stage electronic circuit theory of ECG/EKG systems. Be heart smart and learn at the same time! Simple and safe 9V Battery operation.

ECG1	**Electrocardiogram Heart Monitor Kit**	**$39.95**
CECG	**Matching Case & Knob Set**	**$14.95**
ECGP10	**Replacement Reusable Probe Patches (10-Pack)**	**$7.95**

PLASMA GENERATOR

- ✓ Generate 2" sparks to a hand held screwdriver!
- ✓ Build your own plasma balls!
- ✓ 25KV at 20 KHz from a solid state source!

Generate really impressive sparks, build your own plasma ball, light fluorescent tubes without wires! From a solid state source, generate over 25KV at 20KHz for the most dazzling displays!

PG13	**Plasma Generator Kit**	**$64.95**
PS12	**14VAC Output Power Supply**	**$19.95**

ION GENERATOR

- ✓ Generates negative ions with a blast of fresh air!
- ✓ 7.5KV DC negative, 400uA - that's a lot of ions!
- ✓ Steady state DC voltage, constant current, not pulsed!

Learn the basics of ion repulsion by building this ion generator! Creates a continuous blast of fresh air charged with a ton of ions. Perfect for pollution and air freshening; just smell those ions! Solid state wind generation; you'll be amazed!

IG7	**Ion Generator Kit**	**$64.95**
AC125	**110 VAC Power Adapter**	**$9.95**

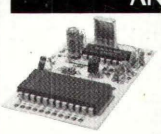
HAND HELD SPEED RADAR GUN

- ✓ Measures speed from 10 to 110 MPH!
- ✓ Switchable US or Metric!

Now YOU can clock that cop car! Uses the same doppler radar technology as their radar guns use. We took it out on the road and set off a LOT of radar detectors and the traffic slowed right down! Requires six AAA batteries not included.

SRG20 Hand Held Speed Radar Gun, Assembled! $89.95

AND...OUR FAMOUS MINI-KITS!



BN9

These are easy to build kits that can be used either stand-alone or as building blocks for more complex projects.

TS4	**Tickle-Stick Shocker**	**$12.95**
BN9	**Super Snoop Amplifier Kit**	**$9.95**
BL1	**LED Blinky Kit**	**$7.95**
TD1	**Tone Encoder/Decoder Kit**	**$9.95**
TT7	**Touch Tone Decoder Kit**	**$24.95**
CPO3	**Code Practice Oscillator Kit**	**$14.95**
UT5	**Universal Timer Kit**	**$9.95**

NEW! EASY-LEARN HOBBY KITS

- ✓ **Build It!**
- ✓ **Learn It!**
- ✓ **Achieve It!**
- ✓ **Enjoy It!**

Learn how AM, FM, and Shortwave radios work! Go back in time, and learn the theory how to use a crystal diode to convert AM radio to audio you can hear! Learn the basics of bells and motors, and actually watch them work! Start a great hobby in electronics with our 130 in 1 Electronic Lab, and build a radio, radio broadcaster, electronic organ, kitchen timer, logic circuits, and much, much more! All kits are solderless, using spring-coil connections, making it safe and easy for anyone to build. Detailed step-by-step instructions are included to guide you through the entire project. Learn about electronics and study the wonders of science today!

AM2	**AM Radio Kit**	**$14.95**
AMFM7	**AM/FM Radio Kit**	**$19.95**
SR3	**Shortwave AM Radio Kit**	**$19.95**
CS2	**Crystal Radio Kit**	**$9.95**
BA1	**Bell Action Kit**	**$8.95**
MA1	**Motor Action Kit**	**$8.95**
PL130	**130 In One Electronic Lab Kit**	**$39.95**

PROFESSIONAL FM STEREO RADIO STATION

- ✓ Synthesized 88 to 108 MHz with no drift !
- ✓ Built-in mixer – 2 line inputs, one microphone input, line level monitor output!
- ✓ High power module available for export use
- ✓ All new design for 2002!

Introducing the FM100B, the all new design of our very popular FM100! Designed new from the ground up, including SMT technology for the best performance ever! Frequency synthesized PLL assures drift-free operation with simple front panel frequency selection. Built-in audio mixer features LED bar-graph meters to make setting audio a breeze. The kit includes metal case, whip antenna and built-in 110 volt AC power supply.

FM100B	**Super-Pro FM Stereo Radio Station Kit**	**$269.95**
FM100BEX	**1 Watt, Export Version, Kit**	**$349.95**
FM100BWT	**1 Watt, Export Version, Wired & Tested**	**$429.95**

SYNTHESIZED FM STEREO TRANSMITTER

- ✓ All new design & features for 2002!
- ✓ Fully adjustable RF output

NEW!

Our #1 kit for years has just gotten better for 2002! Totally redesigned, the FM25B has all the features you've asked for. From variable RF output, F connector RF output jack, line input, loop output, and more. Includes case, power supply, whip antenna, audio cables.

FM25B Synthesized FM Stereo Transmitter Kit $139.95

FM RADIO STATION BROADCASTER

- ✓ Get on the air for less than $40!
- ✓ Operates on 5 to 15 VDC

You'll be amazed at the exceptional audio quality of the FM10A! Tunable from 88MHz to 108 MHz, the FM10A features line level stereo inputs with RCA phono jacks for easy operation. Order yours today, and get on the air!

FM10A	**Tunable FM Stereo Transmitter Kit**	**$39.95**
CFM	**Matching Case & Knob Set for FM10A**	**$14.95**

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